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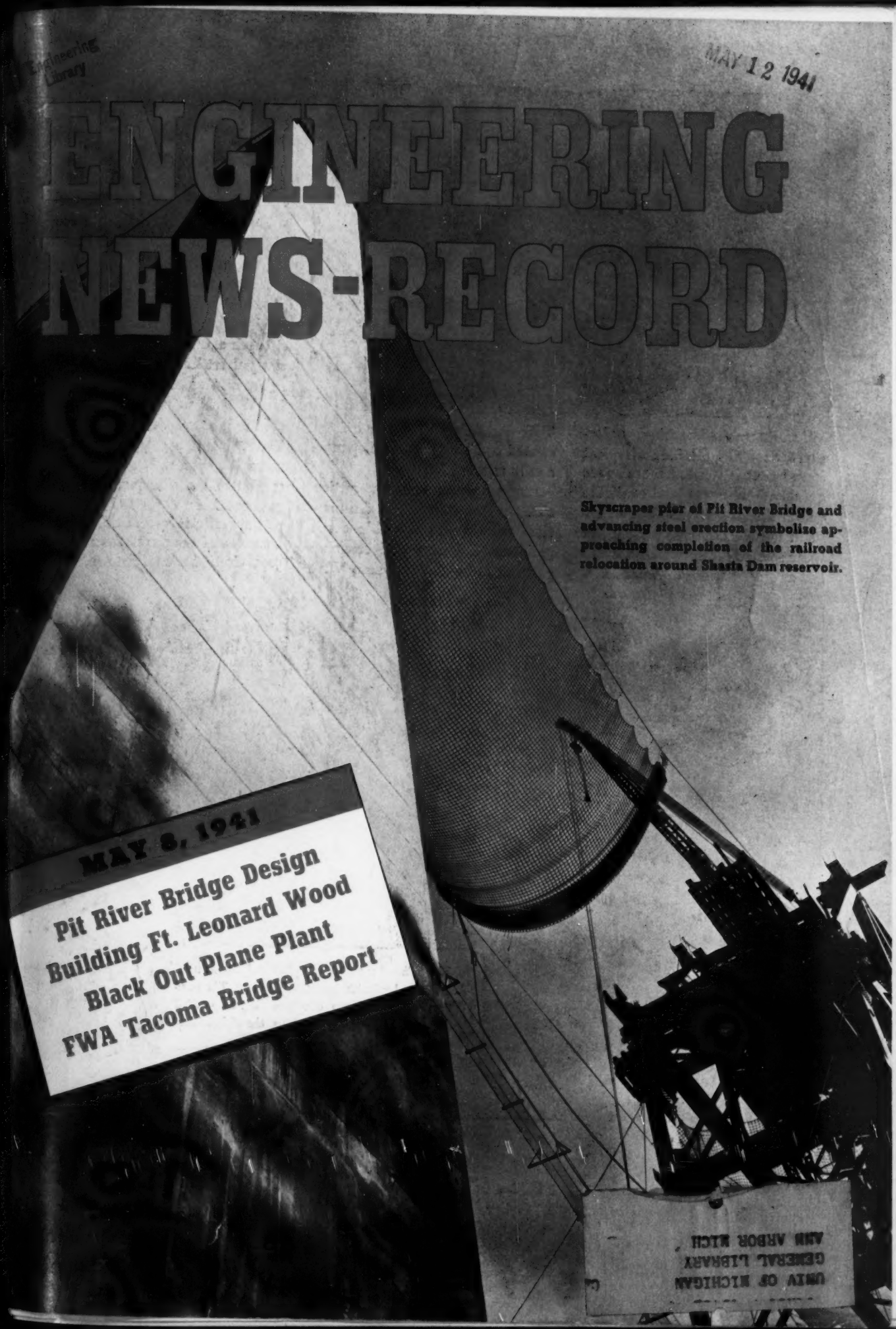

Skyscraper pier of Pit River Bridge and advancing steel erection symbolize approaching completion of the railroad relocation around Shasta Dam reservoir.

MAY 8, 1941

Pit River Bridge Design
Building Ft. Leonard Wood
Black Out Plane Plant
FWA Tacoma Bridge Report

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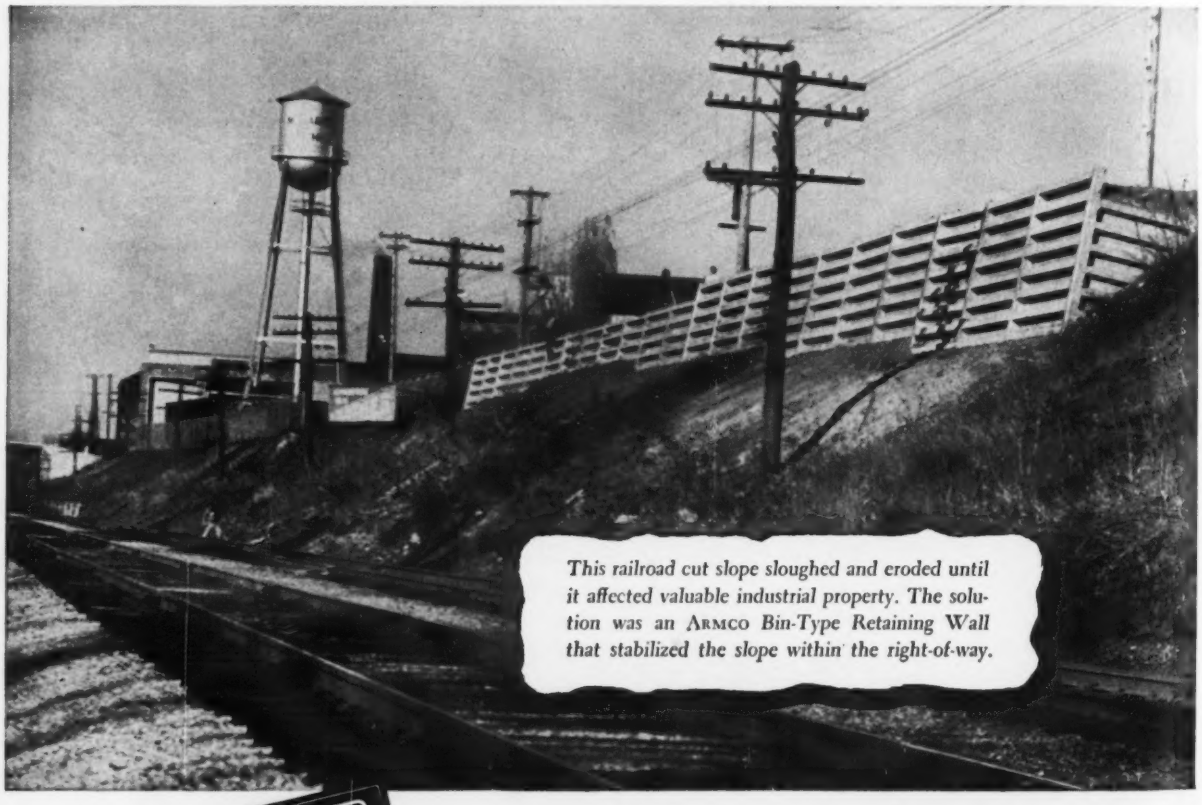

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ARMCO Bin-Type Retaining Walls

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Vol. 126 MAY 8, 1941 No. 19

THIS WEEK

• The consulting board appointed by Federal Works Administrator John M. Carmody has concluded its work and prepared a voluminous report which is abstracted as to official conclusions, supporting data, and essential statistics The report will represent the last official word of the Tacoma disaster and constitutes a new chapter in the technical literature on suspension bridge design.

• Another Army cantonment has been completed in record time and under most difficult conditions of weather and transportation. Ft. Leonard Wood represents another chapter in our continuing reporting of the building projects carried out to house the new Army.

• A sewage treatment plant representing the last word in sludge handling has been completed near Washington, D. C. The elements of this plant and its program of operation are reviewed.

What is the

"ST. LAWRENCE PROJECT"?

Engineering News-Record

will present

A factual 16-page review of the historic background, engineering and administrative aspects and other significant factors bearing on this gigantic power and seaway project which is in the spotlight of professional and public attention.

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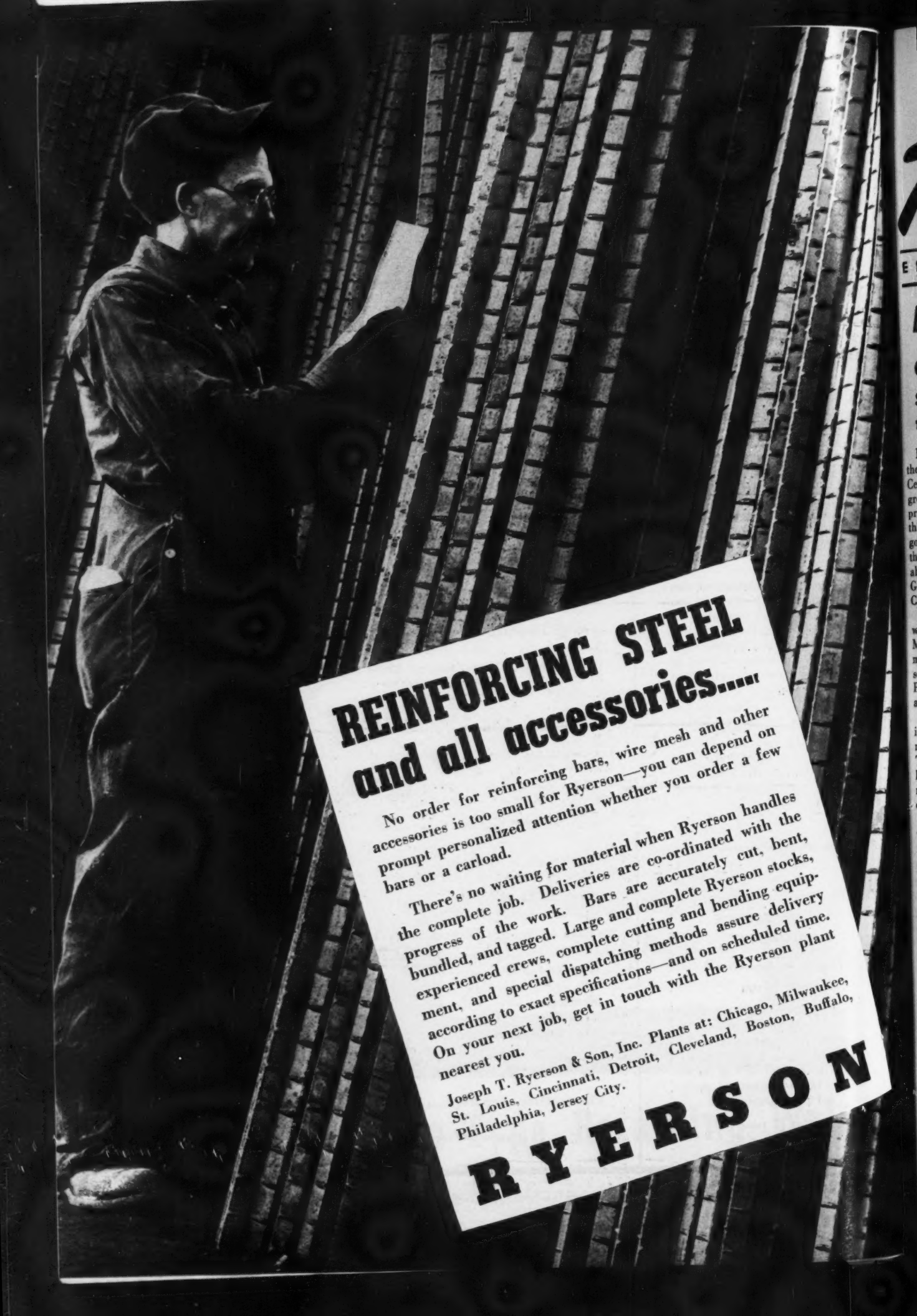
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The Week In Engineering and Construction

President urges completion of Inter-American Highway

Suggests that U. S. contribute $20,000,000 to bring Central American sections up to an all-weather standard

Increased U. S. aid in construction of the Inter-American highway through Central America was urged upon Congress last week by the President. He proposed a $30,000,000 program, two-thirds of which would be met by this government, to bring the highway over the next five years to a standard passable in all weathers from the Mexico-Guatemala border south to the Panama Canal.

At present, the Inter-American Highway is paved from the U. S. border to Mexico City, and the Mexican government is actively pushing work on the southern portion in its territory. The President's plan does not include any aid to Mexico.

South of Mexico, the road is passable in all weathers through Guatemala and most of Honduras and El Salvador. Through Nicaragua and Costa Rica, however, there are long gaps where the road is passable only in dry weather or is a mere trail.

U. S. expenditures to date on the highway include $369,612 of federal-aid funds, most of which was for surveys and engineering, and $1,100,000 of State Department funds to defray the cost of bridges. In addition, the Export-Import Bank has made highway loans to Central American governments totalling $8,800,000. Also, the War Department now has $1,500,000 for construction of the Chorrera-Rio Hato road in Panama, which will form part of the highway.

Preliminary surveys have been made of the entire route and general locations established. (*ENR*—Oct 3, '40. Vol p. 436).

The President's proposal envisions expenditure by this country of $20,000,000 and by the Central American governments of $10,000,000—presumably to be borrowed from the Export-Import bank. About $5,400,000 of U. S. funds would be spent the first year and something under $4,000,000 a year for the next four.

The construction would probably be handled by the highway departments of the Central American governments, with technical assistance from the Public Roads Administration. Usual practice of these governments is to handle such work by contract.

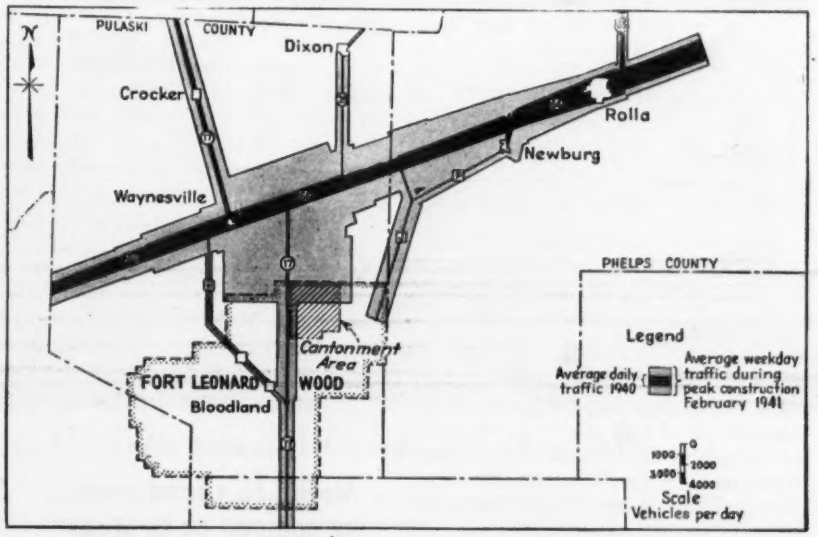
With the available funds it is believed that the entire length of the highway could be graded and drained and a low-type surface such as gravel applied in some sections where needed to insure an all-weather road. To provide an oil-bound surface for the entire road would cost some $51,000,000. In addition to a large number of small bridges, six major structures would be required.

Florida canal favored as post-war project

Busy building up a backlog of post-war construction projects, the House committee on rivers and harbors last week reported favorably a bill authorizing completion of the Florida ship canal. Chairman Mansfield of the committee intends to submit a dissenting report. The committee has also drawn up, but not yet reported to the House, a bill authorizing $282,000,000 worth of navigation projects. In each case the projects are for prosecution after the war.

Among the larger projects to be included in the river and harbor authorization are the following:

Connecticut River between Hartford and Holyoke	$12,344,000
East River, N. Y.	34,509
Savannah River, Ga., and Clark Hill Reservoir	28,000
Tennessee-Tombigbee Waterway	66,000
Illinois Waterway and Indiana Harbor Canal	25,900
Umatilla Dam on the Columbia River	23,700



Diagramming the need for access roads to cantonments

This diagram of the increase in traffic flow in the vicinity of Fort Leonard Wood near Rolla, Mo. during the camp construction period presents a startling picture of the impossible demand placed on existing roads near army concentrations. The Fort Leonard Wood access situation shows the need for immediate relief at present camps and better preliminary planning at future military concentrations.

The width of black lines shows normal traffic density (average daily flow) during 1940 and the width of gray lines indicates the corresponding traffic in February, 1941, while camp construction was at its peak. Added demand on the through highway (U. S. 66) approaching the camp vicinity is mild compared to the overload placed on the principal access road, state highway 17.

New Tacoma toll bridge authority being organized

A new development in proposed reconstruction of the Tacoma Narrows suspension bridge came last week with the announcement of Harry P. Cain, mayor of Tacoma, that he shortly will organize a Tacoma Toll Bridge Authority.

A group of citizens will be incorporated to handle the financing and management of the bridge reconstruction; this group will apply to the state for a certificate of necessity for operation of a toll bridge during the life of its financing, after which the span would be turned over to the state as a toll-free structure.

The Washington State Toll Bridge Authority, builder of the bridge which collapsed last fall, is engaged in a court controversy with insurance companies, which Mayor Cain fears may last for years.

The mayor has declared at least three big insurance companies have offered to finance the structure if it is rebuilt under private management. Cost of the new structure is placed at somewhere between ten and $12,000,000.

Mayor Cain states that he has been assured by engineers that the piers of the old bridge are in perfect condition and ample to carry a span 50 percent or more larger than the span which collapsed.

"We believe that Tacoma's entrance into the bridge construction will be a relief to the state toll bridge authority," the mayor said, "as it will take reconstruction out of the picture and leave the state free to make the best settlement possible for the loss of the original structure."

• • •

Bids to be opened in June on Clearwater Dam work

U. S. Army Engineers have announced that bids will be opened June 3 on the second phase of construction for the $10,000,000 Clearwater Dam project on the Black River near Piedmont, Mo.

The second phase calls for construction of an earth dam 4,200 ft. long and excavation for spillways. The first phase, construction of outlet works for diversion of the stream, is now under way on contracts let several months ago. The third phase will be construction of the spillways.

Advance notices being sent to contractors state that bids will be considered for two types of construction on the dam—roll fill and hydraulic fill. The top of the dam will be approximately 150 ft. above the base.

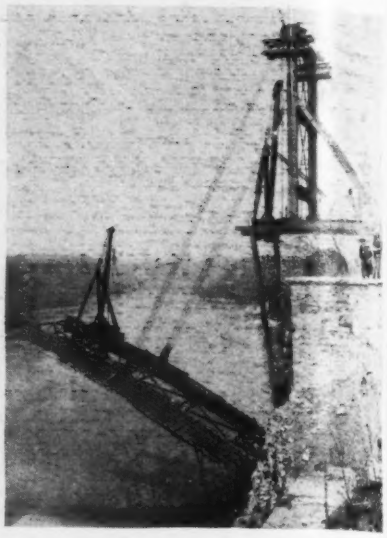
Major items in specifications for the roll-fill type dam and spillways call for common excavation of 6,310,000 cu.yd. of earth and 366,000 cu.yd. of rock excavation. For a hydraulic fill dam, the major items will be 2,331,000 cu.yd. of common excavation, 366,000 yd. of rock excavation, and 5,619,000 yd. of fill.

Major T. F. Kern is U. S. District Engineer at Little Rock, Ark. under whose jurisdiction the Clearwater Dam project is being constructed.

• • •

Maine to spend over $2,000,000 on bridges

The Maine Senate has authorized a $2,000,000 bond issue, proceeds of which will be used in conjunction with federal funds to rebuild and strengthen bridges designated as important to national defense. It is understood that Governor Sewall approves of the measure and will affix his signature to the bill authorizing the bond issue.



Steel arch for Rainbow Bridge complete next week

Under a rapid construction schedule, engineers for Rainbow Bridge over the Niagara River between the U. S. and Canada, Niagara Falls, N. Y., expect to have the arch complete sometime next week. Out of 24 sections in the arch, only a few remain to be placed.

This new structure, costing approximately $3,760,000, will be the longest fixed-end arch bridge in the world, and is being erected to replace the old Falls View or "Honeymoon" bridge destroyed by ice in January, 1938. (See ENR—Jan. 9, 1941, Vol. p. 58.) The structure is being constructed about 400 ft. north or downstream from the site of the old span. The new crossing is 1,450 ft. long, including a 950-ft. steel arch. The deck width is 60 ft. overall with two 22-ft. roadways separated by a 4-ft. mall plus a 10 ft. sidewalk on the upstream or Falls side. The center of the skewback at the abutment is 55 ft. above low water (El. 337 mean sea level) or about 29 ft. above the elevation of the pin centers of the old Falls View bridge.

At the left, in the illustration above, is shown construction progress in Ontario as of April 12, while the view on the right is of the American side on the same date.

Bethlehem Steel Co. has the $1,452,000 contract for the main arch span. Other contractors on the work are: McLain Construction Co., Buffalo, and Aiken & MacLachlin, St. Catherines, Ont.

The Edward P. Lupfer Engineering Corp., Buffalo, is supervising construction, and Waddell & Hardesty, New York, prepared the plans for the project. Aymar Embury, 2nd, New York City, is architect. The bridge is being constructed by the Niagara Falls Bridge Commission, and the schedule calls for completion of the structure by September.

Construction equipment on eligible priority list

Several items of construction equipment are included in the latest revised edition of the "critical list" of items eligible for priority ratings under the so-called automatic system administered by the Army and Navy Munitions Board. Significance of this is, first, that these items are becoming hard to get. Their inclusion on the critical list means that Army and Navy orders for such equipment automatically take precedence over civilian orders. Moreover, a contractor doing construction work for the Army or Navy who needs to buy such equipment can obtain a priority rating on his order by application to the Army or Navy officer in charge of his contract.

The items effected are: Bulldozers, cranes, power hammers, power and hand hoists, blasting machines, and pumping sets.

District of Columbia highway survey recommends $44,450,000 program

Report is unique among highway planning surveys in that it deals with municipal rather than rural roads

A preliminary report by H. C. Whitehurst, District of Columbia director of highways covering the District's share in the highway planning now being carried on by the states in cooperation with the federal government recommends a $44,450,000 program of road improvement to be undertaken over the next eight years. This cost, it is suggested, might be financed by a two-cent increase in the district gasoline tax. The report is unique among the highway planning surveys in that it deals with municipal rather than rural roads.

Most of the through traffic to be handled is moving north and south along U.S. route 1. To deal with this, the report recommends use of a road through the eastern section of the city, by-passing the central business district. This would require construction of a $4,500,000 bridge over the Anacostia River together with widening of existing streets. The bypass road would not be grade-separated, but would be paralleled by local service lanes, and, since through much of its length it skirts the Anacostia River, it would be relatively free of intersections.

To improve the handling of local Virginia traffic coming into the district, construction of a $9,500,000 two-lane tunnel under the Potomac River in the neighborhood of Alexandria is proposed.

For internal circulation of traffic the major recommendation is a series of more or less radial roads connecting the business section with outlying areas.

The most striking proposal in this connection is the creation of an off-grade east-west express highway along the line of K Street to connect with the northwest area. This would in part be elevated and in part depressed.

The other radial roads do not involve this freeway type of construction. The major problem in these, since Washington streets are already wide, is elimination of friction at intersections. An extensive program of separating grades at major intersections on the radial system is proposed, as well as grade separation at some seven other important intersections. The traffic circle system generally used in Washington for handling intersecting traffic is now recognized as inadequate at congested locations. The solution to be adopted is in general to relieve traffic on the circle by putting whichever of the tributary streets has the largest through traffic into a tunnel under the circle.

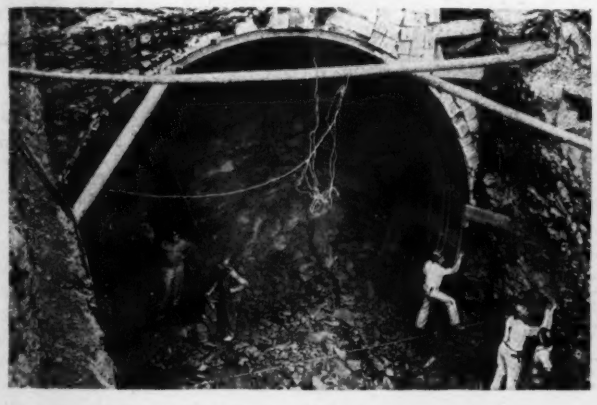
The width of Washington streets makes is possible to carry out this program, including the grade separations, with almost no acquisition of land.

The report also includes preliminary recommendations based on a study of the parking problem in Washington. Major suggestion is establishment of municipal parking lots on the fringes of the central area in conjunction with short-line bus service from the lots to the major government buildings.

• • •

Minnesota increases gas tax to expand road funds

Minnesota's Senate and House have passed a bill increasing the gas tax to 4 cents, and the state's one-mill road and bridge levy was repealed. The new arrangement will relieve the pressure of taxation upon real estate in Minnesota, and at the same time it will provide an estimated gain in highway revenue totaling about $3,800,000. Anticipated additional income of $5,000,000 from the increased one-cent tax on gasoline will produce added revenue above the $1,200,000 loss from the repeal of the road levy. The governor is expected to approve the measure.



Conduit for Blue Mountain Dam outlet works nears completion

Construction of the conduit for the outlet works of Blue Mountain Dam, which is being erected on Petit Jean River in Yell County, 1½ miles southwest of Waveland, Ark., is expected to be complete by mid-July. The dam has been designed to prevent flooding of the river valley downstream for approximately 60 miles to the confluence of the Petit Jean River with the Arkansas River. The Blue Mountain Dam project was authorized by Congress as one unit of the comprehensive flood control program for the Arkansas and White River valleys.

Approximately 325,000 cu.yd. of excavation will be required for the outlet tunnel and the channel through which the water will flow until it rejoins the main stream. The concrete lined tunnel will be 20 ft. in diameter and about 1,000 ft. long. Some 23,000 bbl. of cement and 1,600,000 lb. of steel will be used in its construction. During construction of the dam, the water of the Petit Jean River will flow through the tunnel, and after the dam is completed the tunnel will be utilized in releasing impounded water from the reservoir.

The outlet work is now about one-fourth complete, according to Major T. F. Kern, of the U. S. Engineers, and it is expected that work will begin early this summer on the earth section of the dam. The dam will be a rolled earth embankment 2,700 ft long with a maximum height of 115 ft. The reservoir will have a total storage capacity of 258,000 acre-ft., of which 233,000 will be for flood control and 25,000 for conservation.

John Kerns Construction Co., Omaha, Neb. has the contract, and 27 members of the staff of the U. S. Engineers are serving as inspectors. Major T. F. Kern is district engineer at Little Rock, Ark.

Waterworks defense to feature AWWA meeting

Water supply and national defense will be highlighted on the convention program of the American Water Works Association to be held in Toronto, Canada, on June 22–26. Harry E. Jordan, secretary of the association, has announced that an internationally known leader in the field of water supply will describe the situation in which British overseas water plants have found themselves during the present conflict.

Other features of the convention will include discussion on civil service matters and pending social security legislation, current practices relating to protective grounding of electric circuits, and the proposed revision of the U. S. Public Health Service standards for drinking water.

• • •

First welding conference held in New England

Massachusetts Institute of Technology was host to the first New England Welding Conference, a meeting sponsored by the Institute and the Boston Section of the American Welding Society, April 25-26. Chairman of the meeting was Prof. P. E. Kyle, and of the eight papers presented several related to structural engineering problems. J. H. Zimmerman (Linde Air Products Co.), in discussing modern applications of flame-cutting processes, described how the preparation of the edges of butt weld grooves can be done by machine gas cutting and flame machining. He also emphasized gas gouging as a more economical method than chipping for cleaning out the roots of butt welds before back-welding them, and for the removal of defective welds.

In a paper on weldability of steel, W. G. Theisinger (Lukens Steel Co.) discussed the effect of speed of welding and of composition, particularly that of carbon and manganese, the effects of which are now being investigated as a research problem at Battelle Memorial Institute, Columbus, Ohio.

Finally, in a paper on the welding of steel structures, La Motte Grover (Air Reduction Sales Co.), pointed out the trend toward standardization of welding procedures and qualification of welding operators, regardless of the kind of steel fabrication involved. A trend to wider use of welded rigid frame and arches for factories was also noted. Mr. Grover pointed out that poor economy results when both rivets and welding are used in the same structure, because of the additional handling necessary in the shop. Also for flat-position welding in the shop the special electrodes designed for this purpose should be used rather than an all-position type of electrode.

JOBS OF THE WEEK

GENERATING PLANT, Moncure, N. C.
Lee Construction Co., Charlotte, has been awarded contract by Carolina Power & Light Co., Raleigh for substructure of generating station; Virginia Bridge Co., Roanoke, Va., will build superstructure. Gregory & Poole, Raleigh, will construct canal. Total estimated cost $3,000,000. Ebasco Services, Inc., New York, is engineer.

AIRCRAFT ENGINE ASSEMBLY PLANT, South Bend, Ind.
Consolidated Construction Co., Chicago, Ill., will construct 1 story, 762x1,147 ft. aircraft engine assembly plant, for Studebaker Corp., $2,661,212. Giffels & Vallet, Inc., Detroit, Mich., are architects. Total estimated cost $20,000,000.

DRYDOCK, Portsmouth, N. H.
Aberthaw Co., Boston, Mass., has been awarded contract for the construction of a drydock at Navy Yard, here, by Bureau of Yards & Docks, Navy Department, Washington, D. C., $2,500,000.

AIRPLANE PARTS PLANT, Chicago, Ill.
S. N. Nielsen Co., Chicago, Ill., will construct 1 story, brick, steel, airplane parts manufacturing plant, for Studebaker Corp., South Bend, Ind., at cost of $1,013,700. Total estimated $12,000,000. Giffels & Vallet, Inc., Detroit, Mich., are architects.

TRESTLES, Louisiana
Brown & Root, Inc., Houston, Tex., was lowest bidder constructing rein.-con. trestles, on timber foundations, 18,750 ft. long in floodway and 312 ft. long in east filled approach for high level crossing of railway over Morganza Floodway, for New Orleans, Texas & Mexico Railway, Houston, Tex. Estimated cost $2,198,389.

DEFENSE HOUSING, Bridgeport, Conn.
Maurice L. Bein, Inc., Chicago, Ill., has been awarded contract for the construction of three hundred units National Defense Housing, Boston and Success Aves. by Bridgeport Housing Authority, for FWA. $1,776,000. T. Vece is architect. A. D. Ciresi, and Fletcher-Thompson Co., Inc., Bridgeport, are engineers.

EARTHEN DAM, Waveland, Ark.
Myers, Myers & Goen, Salem, Ind., was lowest when bids were opened April 30 for 2,800 ft. long earthen Blue River Dam, on Pettit Jean River, near here, at $1,111,879. U. S. Engineers, Little Rock, Ark., took bids.

HOSPITAL, Springfield, Mo.
Swenson Construction Co., Kansas City, Mo., will build O'Reilly General Hospital, including ninety-eight frame buildings, permanent administration building, for War Department, Washington, D. C., $1,713,500. J. W. Radotinsky and Gentry & Voskamp, Springfield, are architects.

SHIPWAYS, Beaumont, Tex.
Pennsylvania Shipways, Inc., Beaumont, constructing three shipways by separate contracts and force account. Estimated cost $1,250,000. U. S. Maritime Commission, Washington, D. C., will finance.

SHELL LOADING PLANT, Ravenna, O.
Hunkin Conkey Construction Co., Cleveland, O., will construct additional building, at shell loading ordnance plant, for War Department, Washington, D. C. Estimated cost $5,000,000. Wilbur Watson and Associates, Cleveland, O., are engineers and architects. Atlas Powder Co., Wilmington, Del., will operate.

PIER, Galveston, Tex.
Kansas City Bridge Co., Kansas City, Mo., was lowest bidder when bids were opened April 30, for pleasure pier, 1,300 ft. long x 102 ft. including theatre, exhibition building, for City of Galveston, $1,287,500. Robert J. Cummins, Houston, is engineer.

PIER, Bremerton, Wash.
A. W. Quist and Sound Construction & Engineering Co., Seattle, Washington, was lowest bidder on a rein.-con. pier for Puget Sound Navy Yard. $1,283,000 was the low offer, when Puget Sound Navy Yard took bids April 30.

NON-COMMISSIONED OFFICERS' QUARTERS, Anchorage, Alaska
U. S. Engineers, Seattle, Washington, will construct non-commissioned officers' quarters at Fort Richardson by force account. Estimated cost will be $1,600,000.

NOTE—Additional bidding and contract news on over 800 projects large and small appear in the Construction News section beginning on page 143.

PRA defense road report will soon go to Congress

Recommendations of the Public Roads Administration as to construction of defense highways are still on the President's desk waiting transmission to Congress. It is now believed that the report will be sent to the Hill quite soon, substantially without changes, although the delay has of course lost a large part of the construction season. Meanwhile, however, a certain amount of defense road construction has gone forward with funds already available.

About $19,000,000 worth of work on access highways to military reservations and industrial centers was under way the first of this month with federal-aid funds. Although no definite figures are available it is believed that something like $35,000,000 of WPA work is being done on access roads; this includes several high-type roads, but is largely made up of grading and low-type surfacing, to which paving can later be applied.

About 55 percent of the regular federal aid projects started from December through March—a total of $31,245,000—were either access roads or were on the strategic highway network. Nearly 60 percent of these started this year fall in this defense category. In the secondary road program only about 10 percent—$826,000—are defense roads, while 36.6 percent of grade crossing elimination projects started December-March are on defense roads. The figures given for primary and secondary federal defense work include only the federal contribution and are matched by equal amounts from state funds.

• • •

Congress gets $150,000,000 civil works program

Legislation authorizing federal subsidies for municipal facilities in defense areas was reported to Congress last week after being held up in committee since February. The bill reported by the House committee authorizes a $150,000,000 program and assigns the administration of the program to the Federal Works Administrator. Expenditures under the act could only be undertaken in localities concerning which the President finds that "an acute shortage of public works . . . exists or impends which would impede national defense activities."

Machinery for administering the program is left very flexible. Loans or grants in any proportion could be made to public or private agencies for construction of new public works or, preferably, enlargement of existing works. Contributions could also be made to public or private agencies for the operation of new facilities. In event that local agencies are unable to carry out the work, even with federal assistance, the Federal Works Agency can itself construct public works and either lease or operate them.

Contracts for construction could be let by negotiation on a fee basis. Prevailing wage payment, and observance of an eight hour day with time and a half for overtime is required.

Construction of any facility useful or necessary for carrying on community life could be undertaken under this bill, but it is intended that the money go chiefly for schools, hospitals, water and sewerage facilities, and streets and roads. In negotiating its loans and grants, FWA is forbidden to set any conditions as to methods of operation of schools and hospitals.

• • •

Detroit housing bids called for June 3

The Detroit Housing Commission announces bids will be received up to 2 p.m., June 3, at Room 500, Water Board Building, for the completion of the $8,000,000 Herman Gardens housing project. The original contract, upon which work had been started by Lipman Const. Co. and A. Smith & Co., Chicago, was voided by graft indictments (*ENR*, Apr. 10, p. 518; Apr. 24, p. 590). Bid deposit of 2½ per cent is required. Plans and specifications may be obtained from Geo. D. Mason Associates, architects, Detroit. The contract for completion of this project will include foundation repairs of frost damage on work already in place.

Loftis suit against A.G.C. dropped by agreement

By mutual agreement, suits involving the alleged expulsion of V. P. Loftis, Charlotte, N. C., contractor, from the Carolinas branch of Associated General Contractors of America, were ended in the superior court at Charlotte last week. Trial of the litigations had been under way for several days when attorneys for both sides agreed to drop the suit.

Loftis, who voluntarily resigned as executive secretary of the Carolinas A.G.C. branch in 1937 to enter business for himself as a building contractor, alleged that he was expelled from membership in the association in August 1938 without due cause and notice and that certain officials of the body had conspired to "ruin" his business by preventing him from obtaining performance bonds and by causing the War Department to remove him from the list of approved contractors. He sought damages totaling $300,000, naming as defendants the Carolinas branch of the A.G.C. and eleven contractors—members of the A.G.C. A non-suit motion was upheld on the conspiracy claim.

The defendants in the Loftis suits filed a counter-claim in which they asked that the court award them certain monies which they said were owing the Carolinas branch of the Association by Loftis as a result of his tenure of office as executive secretary. Loftis denied that he owed the group any money.

Wide World Photo

Mixing cement with granite chips for plane storage area

Variety of equipment mixes eight percent by volume of cement with disintegrated granite from a local pit to make 75,000 sq. yd. of surfaced area for storage of planes at the Army Air Corps bases near Charlotte, N. C. A surface enrichment of twelve percent by volume of cement is added to the top inch.

Construction of the storage areas was completed April 30. Construction at the camp site, including this area paving, is being done by Good Construction Corp. and Blythe Bros. Co., Inc., both of Charlotte, under a $1,187,000 contract, supervised by the U. S. Engineer Dept.; Capt. H. G. Gerdes is in charge.

OBITUARY

A. C. BEYER, district manager, Wallace & Tiernan Co., at San Francisco was killed in an automobile accident April 30. He was an honor student at the University of California in civil engineering and after graduation in 1924 made rapid progress in the sanitary engineering field, being particularly active in the California Sewage Section, A.W.W.A., and the California Sewage Works Association. He was a recognized and popular leader in engineering society activities of the San Francisco Bay region.

CHARLES T. CARPENTER, member of the Pennsylvania Turnpike Commission, died April 30 at Philadelphia, Pa.

WILLIAM H. SANFORD, 61, construction engineer, died May 1 at Philadelphia, Pa. Mr. Sanford was a graduate of Drexel Institute.

COL. WILLIAM J. HOWARD, engineer, died at Whitman, Mass., on May 1. Col. Howard was in charge of construction of the U. S. Army cantonment at Shelby, Miss., during World War No. 1.

FRANCIS L. SELLEW, engineer for the department of public works of Boston, Mass., died April 12. Mr. Sellew had been with the department for 34 years.

MURK FINDLEY, 79, engineer, died at Tuscaloosa, Ala., recently. Mr. Findley was prominent in railway and waterway construction.

RICHARD CLAXTON NEWBOLD, assistant chief engineer of the Pennsylvania General State Authority, died May 1 at Philadelphia, Pa. Mr. Newbold was 56 years old and a graduate of the University of Pennsylvania, class of 1908.

JABEZ G. GUTHRIE, 59, city engineer at Graham, N. C., died April 27.

MARK ORLIN COREY, 68, engineer, died April 19, at Los Angeles, Calif. Mr. Corey had been with the Utah Construction Co. for many years.

WILLIAM M. JONES, 49, public relations director of the North Carolina State Highway and Public Works Commission, died April 20, at Raleigh, N. C.

CONTRACTS AND CAPITAL

ENGINEERING CONSTRUCTION awards for the week, $72,241,000, top the volume for the corresponding week last year by 41 percent, but are 40 percent lower than last week.

Private awards are 31 percent higher than last year, and 12 percent above last week. Public construction is up 46 percent compared with a year ago, but is 50 percent below the total for a week ago.

The current week's volume brings 1941 construction to $2,034,477,000, an increase of 110 percent over the corresponding period last year. Private awards for the 19-week period are 64½ percent higher than a year ago. Public construction records a gain of 135 percent over the 1940 period, due to the 776 percent increase in federal work.

In the classified construction groups, gains over the week last year are in waterworks, sewerage, commercial building and large-scale private housing, public buildings, and unclassified construction. Increases over last week are in sewerage, commercial buildings, and earthwork and drainage.

New capital for construction purposes for the week totals $157,025,000. This compares with $11,298,000 reported for the week last year. The current week's volume is made up of $150,000,000 in federal appropriations for defense housing, $6,652,000 in state and municipal bonds, $300,000 in RFC loans for industrial construction, and $73,000 in RFC loans for public improvements.

CONTRACTS

(Thousands of dollars)

	Week Ending May 9 1940	May 1 1941	May 8 1941
Federal	$7,534	$69,107	$24,391
State & Municipal	26,023	29,578	24,577
Total public	$33,557	$98,685	$48,968
Total private	17,821	20,740	23,273
TOTALS	$51,378	$119,425	$72,241
Cumulative 1941	(19 weeks)		$2,034,477
1940	(19 weeks)		$967,681

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1940 19 weeks	1941 19 weeks
NON-FEDERAL	$403,193	$347,731
Corp. Securities	70,678	108,962
State & Mun.	248,573	198,705
U.S.H.A. loans	78,430	13,521
R.F.C. loans	5,512	26,543
FEDERAL		$2,868,837
TOTAL CAPITAL	$403,193	$3,216,568

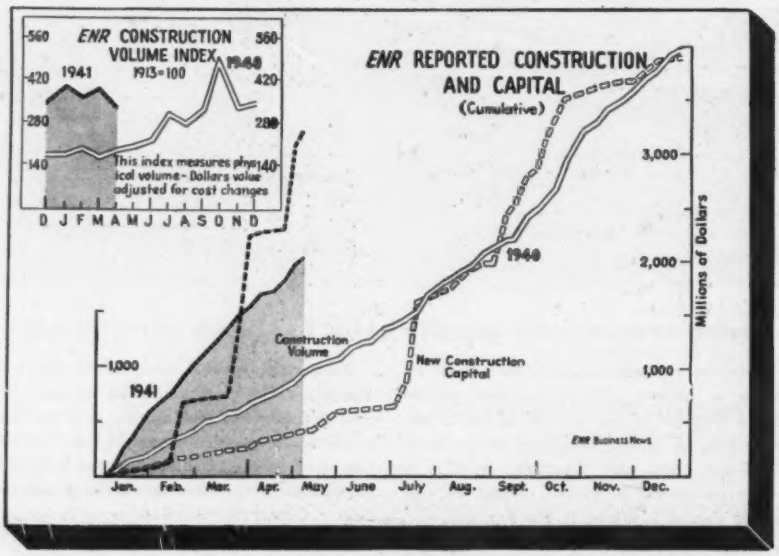
FHA MORTGAGES

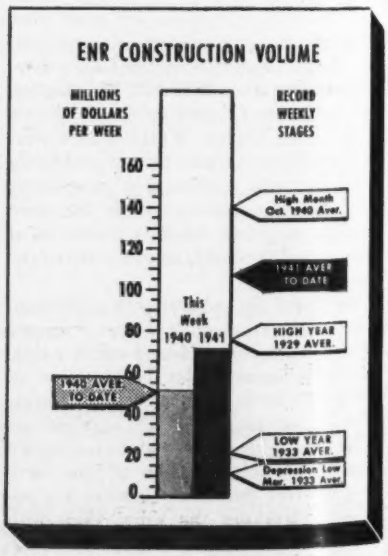
	Week Ending May 4 1940	Apr. 26 1941	May 3 1941
Selected for appraisal	$30,545	$36,154	$33,696*
Cumulative 1941	(18 weeks)		$486,667*
1940	(18 weeks)		$415,031

* Subject to revision.

ENR INDEX NUMBERS

Index Base=100		1913	1926
Construction Cost	May '41	255.55	122.84
Building Cost	May '41	209.24	113.11
Volume	Apr.'41	322	141


ENR CONSTRUCTION VOLUME INDEX 1913=100
1941
1940
This index measures physical volume - Dollars value adjusted for cost changes
D J F M A M J A S O N D
ENR REPORTED CONSTRUCTION AND CAPITAL
(Cumulative)
Construction Volume
New Construction Capital
1941
1940
Millions of Dollars
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.


ENR CONSTRUCTION VOLUME
MILLIONS OF DOLLARS PER WEEK
RECORD WEEKLY STAGES
This Week 1940 1941
High Month Oct. 1940 Aver.
1941 AVER TO DATE
HIGH YEAR 1929 AVER.
1940 AVER. TO DATE
LOW YEAR 1933 AVER.
Depression Low Mar. 1933 Aver.

Comment and Discussion

Readers' opinions on matters that concern engineers and contractors

ALKALI CEMENT AND PARKER DAM

Sir: We know of only two cases where restrictions have been placed on the alkali content of cement. One of these is in the specifications of the state highway department of California, and the other is in specifications of the U. S. Corps of Engineers for Norfork Dam in Arkansas.

In the case of the California specifications, the limit on the alkali content was required only for cements in use in those sections of the state where certain aggregates, which have been found to have some reaction with cements high in alkali content, predominate. This seemed to us to be a very logical procedure and one which we are hoping will prevail in other places where some restriction in the alkali content of the cement seems necessary.

Your magazine ran a brief review of studies emanating from the California Highway Department in February of last year. A more complete report was presented by Mr. Stanton in a paper before the Am. Soc. C. E., *Proceedings*, December, 1940.

Our attention was called to the specifications for Norfork Dam as soon as the bids were requested for the cement. We spent a good deal of time with the engineers interested in an effort to have the specifications amended because we were able to show that there is no justification for the limitation on the alkali content in this particular instance. We had a good deal of support for our position from the Army Engineers, but as you know it is rather difficult to have a specification changed once it has been issued, so that finally the specification stood with a limit on the total alkali content of 0.75 percent.

An unfortunate situation in this whole study has been the use of the term "chert" which Mr. Stanton applied in the description of one of the materials he found to be a source of disruptive expansions when used with cements high in alkali content. This was immediately seized upon by engineers in the east and middle west where cherts as aggregates are very much in disfavor. It was immediately thought that part of the trouble with the cherts in these sections was due to some reaction of the alkali with the cement. This was probably one of the reasons that the alkali limit crept into the specifications for Norfork Dam because of the prevalence of cherts in that whole region.

We have gone into this subject quite extensively, as have also some of the state highway departments where cherts are a matter of serious concern. In no case in our tests have we found that these Mississippi Valley cherts produced the type of reaction which Mr. Stanton was the first to point out, and which now the Bureau of Reclamation has found to be the cause of the cracking in Parker Dam pointed out by Mr. Blanks. Nor have we seen any evidence of such reaction in the experiments by any of the state highway departments mentioned above.

The cherts in the Mississippi Valley, and by that I include the Tennessee and Ohio rivers, where gravels of this type are particularly common, do cause serious cracking in concrete when the concrete is exposed to repeated freezings in a saturated condition. For several years, the question of chert has been foremost in the minds of engineers, including those of the Tennessee Valley Authority, where the proposal has been made several times to use Tennessee River gravels high in chert content in some of the structures. It is quite natural, therefore, that Mr. Stanton's reference to chert was seized upon by many people who were familiar in a general way with the disruptive effects of our local cherts. The cherts are, of course, almost pure silicas, but they are not the soluble or hydrous form of silica which characterizes the cherts mentioned by Mr. Stanton.

F. R. McMILLAN
Director of Research
Portland Cement Association
Chicago, Ill.

[*Although, as Mr. McMillan states, only two jobs have so far specified low-alkali cement because of its reaction with certain aggregates, the New York City Board of Water Supply, under its cement specification, is said to get a cement with 0.5 percent or less of alkali content computed as sodium oxide. The BWS specification, as written by the late Thaddeus Merriman, restricts alkali in order to obtain a uniform rate of hydration and to protect workmen against alkali burns.*—EDITOR]

Sir: The article by Mr. Blanks should be of much value to concrete engineers as the subject of alkalis in cement is being given close study by many investigators. In the Proceedings of the A.S.T.M., 1935, I was co-author of an article on "Research on Concrete Disintegration" and in this article we call attention to the difference in the alkali content of the two different cements used and it was suggested that "Further study be given to the alkali content in cements to be in concrete subject to extreme exposure and rapid alternations of temperature, etc." Although it was not especially noted in the article the cement with the higher alkali content did not produce durable concrete when used with a certain fine aggregate.

At the present time we do not believe we are far enough advanced in this study of alkalis to put a restriction on the maximum alkali content in cements but the subject is of utmost importance and your magazine is to be complimented on the publication of this timely article.

H. S. MATTIMORE
Engineer of Tests
Department of Highways
Harrisburg, Pa.

Sir: We are giving the subject of alkali content in cement serious study but so far have not reached the conclusion that such a requirement would be justified for general use in our state. We have found certain areas, however, in which concrete made with the available aggregates seems to have undergone progressive deterioration when cement of high alkali content has been used. If concrete construction is planned in the future in these areas, our policy undoubtedly will be to place a limit on the alkali content of the cement unless aggregates of known satisfactory performance with high alkali cements are imported.

BAILEY TREMPER
Materials Engineer
Department of Highways
Olympia, Wash.

Sir: The deterioration of the concrete in Parker Dam, as described by R. F. Blanks in your issue of March 27, parallels the experience of the California Division of Highways as reported in a paper presented at the January, 1940, annual meeting of the American Society of Civil Engineers (*Proceedings*, Am. Soc. C. E., December, 1940, p. 1781) and in the Feb. 1, 1940, issue of *Engineering News-Record*, wherein the cause of certain concrete failures in California structures was traced to a reaction between certain reactive minerals in the aggregate and alkali in the cement.

In the California experience the reaction was even more rapid than in the case of Parker Dam. A portion of the Bradley pavement concrete, constructed in December, 1936, had expanded sufficiently by the spring of 1938, at an age of less than sixteen months, to require extensive repairs, including relief at expansion joints. A wide strip had to be removed to relieve the pressure and correct a serious uplift of the pavement.

More striking, however, than the rapidity of reaction was the small percentage of reactive mineral or minerals in the aggregate. It was definitely determined that in the California case less than 1 percent of reactive mineral was present.

While it is true that the cause of the trouble at Parker Dam is an apparently entirely different rock (igneous) than the sedimentary rocks to which the California highway troubles have been primarily traced, nevertheless it is very probable that the same cause will be ultimately determined as the source of the trouble in each case and that occurrence in the sedimentary rock derives from the breakdown of volcanic rocks similar to those causing the Parker Dam trouble. The limitation of 0.60 percent on alkali content fixed by the Bureau for its large and important works seems to be justified by the tests carried out in connection with the California Division of Highways investigation, as a result of which the conclusion was reached that the intensity of the reaction is approximately proportional to the percentage of alkali in the cement, apparently being of such low order as to be negligible when the total alkali content is less than 0.60 percent. The Bureau of Reclamation engineers are to be commended for the speed and thoroughness with which they have taken up the investigation and the extensive research program now under way. The California studies are being continued in an effort to discover the basic cause of the trouble and to develop accelerated laboratory tests for control purposes.

THOS. E. STANTON
Materials and Research Engineer
California Division of Highways

Tacoma Bridge Model Studies

Sir: Investigation of the Tacoma and other bridges for which small-scale models have been built might be completed with little effort by applying the mechanical analysis at the sections where failure has occurred or might be expected. For fundamentals I refer to the paper, "Structural Analysis Based Upon Principles Pertaining to Unloaded Models," *Proceedings* Am. Soc. C. E., Vol. 103 (1938).

OTTO GOTTSCHALK
Buenos Aires

Stay Systems for Suspension Bridges

Sir: My letter (*ENR*, Feb. 27, 1941, p. 516) was a sincere invitation for open discussion of the subject by the profession. Apparently the only response has been the letter of O. H. Ammann, which you published in the same issue.

In my discussion I listed nine reasons why I believe the Whitestone system of end stays is less efficient and effective than the Thousand Islands system. Mr. Ammann has left eight of these reasons unanswered. They are not complex or abstruse but, on the contrary, most of them are fundamental and elementary and should be familiar to every designer of suspension bridges. Perhaps the most important point is that the Whitestone system of stays helps to bring main span, towers and side-spans into unified harmonic motion, instead of checking such motion. This should be obvious to any suspension bridge engineer, even without the aid of laboratory models. In the Brooklyn Bridge, the diagonal stays are anchored to the tops of rigid masonry towers. It is a mistake to use the same system of stays connected to highly flexible towers.

I am glad to have the atmosphere cleared by Mr. Ammann's admission that the Thousand Islands system of stays was *not* included in his model tests at Princeton. That disposes of impressions previously conveyed that the selection was based on such experimental comparative studies.

Against the nine arguments submitted by me, Mr. Ammann offers two reasons for his choice. One is his assertion that the Thousand Islands type of stays would not decrease the "deflections" to the same extent as the adopted type of stays. We are not discussing *deflections* under load; we are discussing *harmonic undulations* produced by aerodynamic effects. It is assumed that the bridge has otherwise been adequately designed to carry its loading without excessive "deflections."

The other reason advanced by Mr. Ammann against the Thousand Islands system of stays is that he found difficulty in working out a connection of the stays to the cables without exceeding safe frictional resistance of his cable bands. I admit that this might have required some resourcefulness, especially where the cable bands have been closely designed and where the stays are stressed to such high initial tension as he has used. However, any engineer in my organization could have shown him how to do it. Furthermore, Mr. Ammann has made a fundamental error in figuring the relative direction of the forces acting at the cable connection. With the Thousand Islands system of stays, the tangential component is up-hill, toward the towers; it is therefore subtractive, not additive, in relation to the tangential component of the vertical suspender tensions. The effect is to reduce, not to increase, the tangential force that the cable band friction has to resist. Incidentally, the tangential component at the cable band produced by stays of the Thousand Islands type can be made as small as desirable by selection of the panel points for attachment.

Mr. Ammann is also concerned about the eccentricity of the connection of stays to cable. In the three bridges where end stays of the Thousand Islands type have been used, this eccentricity varies from 0 to 3 in. In the mid-span stays of the Whitestone Bridge, the eccentricity at the cable connection, as scaled from the published drawings of the structure,

appears to be approximately 12 in.

Apparently these difficulties were not considered important by Mr. Ammann when he followed the Thousand Islands Bridge precedent to the extent of adopting the unpatented mid-span stays for the Whitestone Bridge. In his installation, the tangential component of one of these stays, using a working stress of one-half of its ultimate strength, is 138,000 lb., and the friction required for equilibrium would be 24 percent of his specified bolt tension; yet he states in his discussion that "safe design would certainly not permit the maximum force acting on the cable band parallel to the cable to exceed 15 percent of the theoretical maximum cable band pressure." The context shows that by "maximum cable band pressure" Mr. Ammann means total bolt tension. Accordingly, by his own criteria of safe design, the mid-span stay connections on the Whitestone Bridge call for review or for constant watching. The inadequacy of the mid-span stays on the Tacoma Bridge (without end-span stays) and the slipping of a cable band to which the mid-span stays were attached are now generally known to have played a part in precipitating the collapse of that structure.

I am not advertising any system of stays. I sincerely hope there never again will be a need for them. I am merely recording a plea for more candor, more professional courtesy, and more open-minded consideration among bridge engineers.

D. B. STEINMAN
Consulting Engineer
New York

Expanded Editorial Service on Buildings

DESPITE THE FACT that in 1940 more pages of *Engineering News-Record* were devoted to technical articles dealing directly with buildings that in any year since the boom era of the late 1920's, service to architects, engineers and contractors interested in building has been further increased in 1941. Such a policy as as old as the paper; whenever a division of the field is active, News-Record's contents reflect that activity. Not to go back too far, the chart of contents during the past two decades shows successive periodic rises of emphasis on flood control, highways, bridges, buildings, concrete dams, flood control again, earthwork and soil mechanics, water supply and sewerage, and now buildings again. Airports may be the next candidate for emphasis.

OUR READERS will recognize in these cycles a reflection of their own experience, wherein they find their activities and interests periodically shifting from one class of work to another. They will, furthermore, be aware that the shifts do not involve extreme specialization, for the sewage works and the water plant require buildings, often very large and pretentious ones; the flood control job requires bridge design and construction; the airport combines highway and building techniques; and the industrial plant needs sanitary and water-supply facilities. In brief, while the job of the moment may have a distinctive label it embodies elements of design and construction practice that are universal. *Engineering News-Record's* publishing policy to fit such a situation is continuous broad coverage of all activities, with special emphasis on any one that may, for a period, be predominate. Indeed, such a policy is mandatory in the civil engineering-construction field if the readers' needs are to be served.

IT IS AS A CONSEQUENCE of the present great surge in building construction that *News-Record's* articles on the various phases of building design and construction have been augmented. The near future will witness a further increase, with more articles like the one on the Chrysler tank arsenal in the April 10 issue, or the one on the North American plane plant in this issue. And on top of this steadily increasing coverage there is to be imposed a vital new service, a section or a series of articles that will be presented under the title of "Building Designer's Library."

BUILDINGS are often thought of as merely enclosed space. They are that, but they are more, because the space is given life by virtue of the special facilities buried under it and supported above it, facilities that vitally influence the whole design of the building and are, in fact, integral with the design. Building Designer's Library will attempt to present for designers and builders the principles and modern practices relating to such building elements as walls, roofs, floors, lighting, heating, fire protection, water supply, sanitation, ventilation, air conditioning. Its contents over a period of weeks should constitute a handbook on the fundamentals of building.

SOME OF THE SUBJECTS planned for Building Designer's Library will include: Fundamentals of Fluorescent Lighting . . . Modern Fire Protection Practice by Sprinklers . . . Air Conditioning for Blackout Plants . . . Principles of Ventilation by Wall and Monitor Sash . . . Design Facts on Acoustical Ceilings . . . Unit Heater Knowledge for Plant Designers . . . Installation Procedures for Insulated Metal Roof Decks . . . Fitting Built-Up Roofing to Service and Climate . . . Design Requirements for Panel Heater Systems . . . Accepted Practices for Glass Block Walls . . . Selecting and Using the New Synthetic Paints . . . Modern Glazing Practices.

THE FIRST INSTALLMENT in Building Designer's Library is published in this issue on page 83.

EDITORIALS

VOLUME 126 NUMBER 19

May 8, 1941

A Good Investment

PRESIDENT ROOSEVELT has asked Congress for $20,000,000 to complete the Inter-American Highway through Central American countries to the Panama Canal. He has proposed this work as a defense measure, and there is little doubt but that such a road would be a help in defending the Panama Canal, provided the agreement under which we contribute a large part of the cost includes a provision that our troops can use it in an emergency without violation of the neutrality of countries through which the road runs. But regardless of the military usefulness of such a highway it would have a high value in our economic defense. On that front we need to do all we can to encourage intercourse between this country and those of Central and South America. A good highway over which our goods and people can move will do much to stimulate intercourse. We could well afford to spend $20,000,000 on the Inter-American Highway even though it had no military value.

Room at the Top

THE PASSING of four railroad presidents in recent months, all of whom began their careers as engineers, serves to direct attention to the number of engineers who have risen to the top in great railroad companies. The most conspicuous example among the living is Ralph Budd, now a member of the National Defense Commission. Those whose careers came to a close in recent months are William B. Storey, former president of the Santa Fe; L. F. Loree of the Delaware & Hudson; Lawrence A. Downs of the Illinois Central; and Duncan J. Kerr of the Lehigh Valley. All started out in minor positions in the engineering departments and rose in those departments to positions where their ability attracted the attention of executives of the companies who drafted them for broader responsibilities. Physical and economic conditions on the railroads have changed since these men started, but there has been no change in the fact that there always is room at the top for men with ability and driving force. If anything, the present depressed condition of the railroads calls for even greater breadth of vision in finding ways to make each dollar of income go farther and produce more traffic. The challenge to young engineers is different from that of the days of railroad expansion but it still is a challenge.

Sludge Disposal Progress

THE VAST STRIDES FORWARD that have been made in the last decade in dealing with sludge disposal find expression in the design of the Anacostia River sewage treatment plant described elsewhere in this issue. And a study of the facilities provided for processing sludge gives clear emphasis to the frequently heard remark that sewage treatment is largely a problem of sludge disposal. In the Anacostia plant we see how this problem is being met through the utilization of processes some of which were unknown and others considered economically questionable less than a decade ago. All of which is indicative of the speed with which the idea of yesterday becomes the practice of today.

Railroad Grade Crossings

SUCH GREAT railroad grade crossing elimination projects as those at Winnetka, Ill., and Syracuse, N. Y., and at Rockaway and on Atlantic Ave. in New York City emphasize the complexity of procedure required to meet the conflicting conditions of such operations. The resulting costs are high, but they are justified by the improvement created. It is well to recall, however, that against the dozen or so crossings eliminated in each of these operations there are thousands of other railroad grade crossings ranking in the class of primary hazards, each one involving a constant threat of death or monetary loss. Elimination of these crossings is one of the biggest single public-works jobs on the national calendar. Its importance was emphasized in this journal at the time the second PWA campaign was in preparation, but the suggestion found little favor with government authorities, and large-scale attack on the problem remains for the future —perhaps for the next big depression.

Highways Too

COSTS AND DIFFICULTIES of railroad grade crossing elimination give a foretaste of what is certain to be experienced in the early future in the field of separating highway crossings. The hazards of road intersections are mounting up rapidly, and per-

haps even now exceed the total of railroad crossing hazards. Separation is relatively cheap if done when the road is being built, but as roadside occupancy becomes denser, especially at and near intersections, costs increase quickly until they may surpass even the cost of railroad crossing elimination. It is gratifying to note an increasing trend toward eliminating intersections at the time of building main routes, but anticipation of coming difficulties and costs would justify a more general adoption of the policy. Otherwise large costs of elimination must be looked for in the early future.

New Suspension Bridge Concepts

THE REPORT OF THE FWA consulting board appointed to investigate the collapse, on Nov. 7, 1940, of the Tacoma Narrows suspension bridge is destined for high rank among important engineering documents. Whether in the future its conclusions are upheld or successfully challenged, it is a milestone in suspension bridge history. The concept of structural damping, upon which major emphasis is placed, is new and fundamental. The greater importance of vertical rigidity and torsional resistance as compared to resistance to horizontal deflection, which the report establishes, if not entirely new is nevertheless in the category of fundamentals that were never very consciously embraced. Exhaustive, forthright, orderly and honest, the report meets the ideals that the engineering profession envisions for such reports, and reflects great credit on its authors, Ammann, von Kármán and Woodruff. Nor should the fact that John M. Carmody, FWA Administrator, made the report possible go unnoticed. He discharged a moral responsibility in no less high professional manner than his board met their assignment.

One sentence in the report can hardly be improved upon as a resume of the characteristics of the wind-wrecked bridge. It is that "the comparatively narrow width gave adequate lateral rigidity, but combined with extreme vertical flexibility the narrowness made the structure extremely sensitive to torsional motion created by aerodynamic forces." In the words "adequate lateral rigidity" is verification of the fact that the bridge was designed to meet accepted requirements. Further proof of conventional adequacy is found in the fact that no member or detail failed until it had been subjected to stresses far beyond those for which it had been designed. For the forces considered, the Tacoma Bridge was in no wise deficient. For the aerodynamic forces that attacked it, it was fatally weak.

The report singles out the slipping of the center cable band on the north side of the bridge as the event that initiated failure by changing the parallel motions of the cables to an out-of-phase motion that introduced torsional oscillation of the deck. This slipping was presumably caused by the fact that tie cables were attached to this band, but the natural inference that omission of the ties would have saved the bridge can hardly be drawn in view of the extreme flexibility of the structure; charts, reproduced with the abstract of the report in this issue, show that the Tacoma Bridge, under extreme live load conditions, had twice the vertical deflection and its deck had four times the tilt of the next most flexible suspension bridge. Longitudinal flexibility wrecked the Tacoma Bridge.

What are the lessons of the Tacoma Bridge disaster? The answer to this question is plain, and quite independent of whether the investigators' reasoning as to the causes of the vertical and torsional oscillations is correct. Whether negative damping (aerodynamic instability), eddy currents or random action of turbulent wind (the latter favored by the board), induced the vertical oscillations is immaterial. Torsional oscillation, likewise, does not require a slipped cable band to start it. These motions are inherent in a longitudinally flexible structure under dynamic wind forces.

But the energy fed into the structure by the dynamic wind forces that tend to create such motions must be safely absorbed. That is the lesson and that is the challenge. More rigid stiffening trusses naturally suggest themselves. More effective tower participation might be useful. Systems of stay cables or supplementary suspenders can be utilized to introduce necessary friction. At any rate, structural damping must always exceed any possible negative damping, and with the problem thus defined there is little reason to doubt that it can be solved. When a Tacoma Bridge once more spans the Narrows, it will be a safe and stable structure. Moreover, when other long, slender suspension bridges are called for, they can be designed with assurance that there will be no repetition of the disaster that befell the first Tacoma Narrows crossing.

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Employees' entrances to the plant are protected by 12-in. concrete bomb baffles and canopies. Note the appearance of the cellular sheet steel exterior walls, which represent an innovation for this type of industrial building.

FACTORIES FOR DEFENSE

Building a Blackout Plane Plant

***Contents in Brief**—Contractors fought mud and bad weather all during the fast construction of the North American Aviation plant near Dallas, Tex. The plant, one of the first of the blackout type to be built by the aviation industry, includes one main building, 904x954 ft., and several auxiliary buildings. It is air conditioned and lighted with fluorescent units. Wall and roof construction is cellular sheet metal.*

IN A COTTON PATCH near Grand Prairie, Tex., between Dallas and Fort Worth, one of the first blackout airplane manufacturing plant to be completed in this country will soon go into production. Known as the Texas unit of North American Aviation, Inc., a General Motors subsidiary, the plant includes the largest industrial room in the world, 904 x 954 ft., and is further notable for being completely inclosed, walls and roof, in celluler sheet steel. Six auxiliary buildings bring the total floor space up to 1,060,085 sq.ft. The entire plant is windowless, air conditioned and artificially lighted with the latest type fluorescent units. Provision has been made for a 900 x 1,000-ft. addition adjoining the main building to the west when and if required. Despite the wettest winter season in years, remarkable progress was made in building the plant.

North American Aviation started the unit as a private venture, awarding a lump sum general contract to James Stewart & Co., Inc., of New York, to be handled by their southwestern office in Dallas. The plant is located near Hensley Air Field, owned by the City of Dallas but leased by the War Department, with the idea of delivering the finished planes to the Army at the field over a connecting runway. After construction started, the plant was taken over by the Defence Commission, to be operated by North American, but the terms of the construction contract were not changed.

World's biggest room

The designers claim the main assembly building is the largest room in the world. It consists of nineteen 50-ft. bays in an east-west direction, one 150-ft. and fifteen 50-ft. bays in the north-south direction, with the 150-ft. bay, for final plane assembly, extending across the north side of the building. This bay is high, 25 ft. floor to trusses; the remainder of the building is 16 ft. clear height. The main roof trusses run north and south, carried on 8-in. and 10-in. wide-flange rolled columns that rest on individual spread footings up to 6 x 6-ft. square and 6 ft. deep. Trusses are light, as they carry only a light roof. Top chords in general consist of two 4 x 4-in. angles, bottom chords are two 3 x 3-in. angles. Transverse trusses are similar in design. Steelwork is divided into four quadrants by expansion joints midway in both directions.

Floors in all buildings are 5-in. reinforced concrete slabs on a 4-in. gravel cushion, with expansion joints 100 ft. apart. The concrete floor in the manufacturing and shop areas is not surfaced. Across the south end of the main building processing rooms are separated from the main room by cement-block partitions. Engineering and departmental offices will be located in a 150 x 300-ft. mezzanine section. Toilet and washrooms are also in mezzanine locations, leaving

the entire floor area for manufacturing purposes.

Wall and roof construction represents an innovation for this type of industrial building. The lower walls consist of a 12-in. thickness of concrete 5½ ft. high, but above this, extending to the roof line, is Robertson cellular metal siding, the cells or corrugations running vertically. This material comes in sheets 24 in. wide which interlock at the sides and which can be cut to length with a power ripsaw. Backing up the metal exterior is a 1-in. fiberboard insulation, carrying a metal liner plate exposed to the interior. The roof is cellular metal deck, insulated with 2½ in. of fiberboard upon which is placed a composition built-up roofing. Light steel purlins spanning between the trusses support the roof deck.

Outside structures

To the east of the main plant is a plane storage building, 150 x 300 ft., with 300-ft. trusses providing an interior free of columns. Sliding doors along the north side of this building disappear into end pockets to allow a 300-ft. clear opening. South of the plane storage are a 100 x 150-ft. drop-hammer shop and a 100 x 250 ft. foundry. South of the main plant are a paint storage building, 100 x 100 ft., a powerhouse, a sewage treatment plant and a million-gallon concrete reservoir. Water supply is from two wells. Facing north, at the northeast corner of the main building, is the plant office, 52 x 150 ft. in plan.

Areas around the buildings on the east are paved with concrete. Parking spaces on the north side for office employees and executives, and a big 525 x 950-ft. parking lot to the west for plant workmen are oiled surface. The City of Dallas built the connecting runway between the plant and Hensley Field.

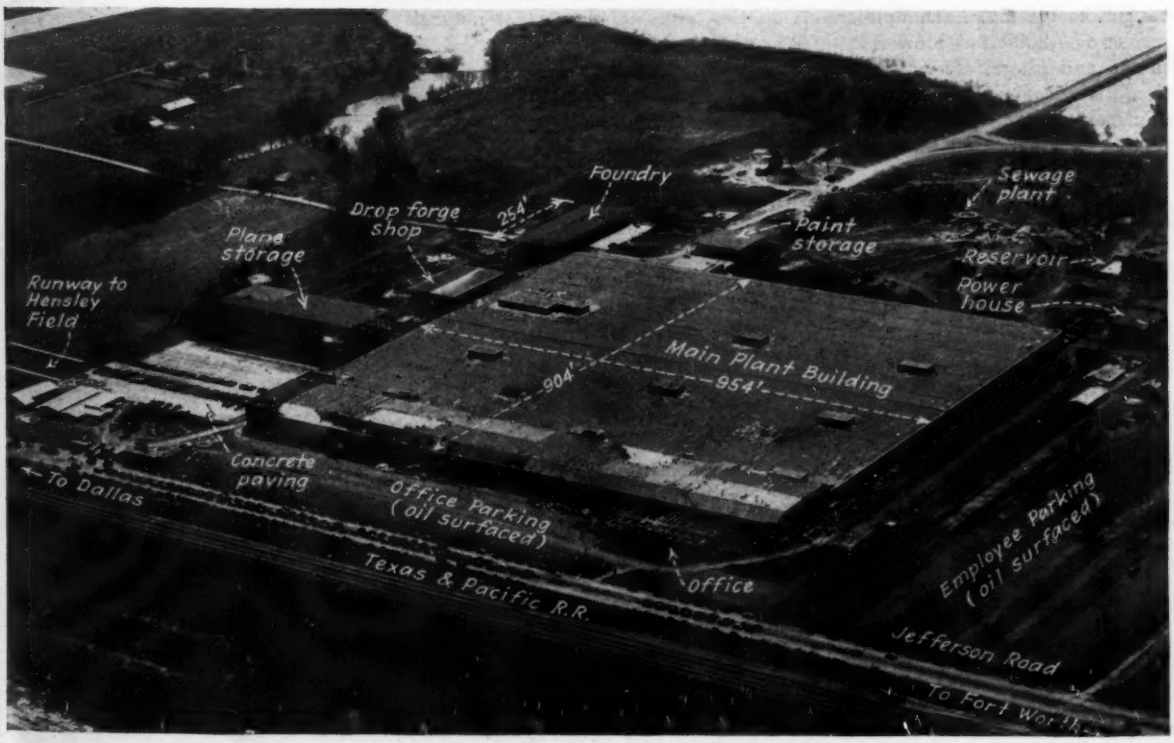
Of course, this type of building construction is not bombproof, but the engineers feel the design minimizes the effect of bombing, for there will be no shattering of masonry in case of a bomb explosion. As a precaution, the main doors to the west, used by employees entering and leaving the plant, are protected by a 12-in. concrete baffle outside the door, 9 ft. high. Explanation of this feature is that bomb splinters from outside explosions cannot enter the doorways.

The plant faces Jefferson Road, formerly the main highway between Dallas and Fort Worth, and the main line of the Texas & Pacific Ry. A railroad spur has been built by the railroad, circling the site to the west and running back along the south side of the main building, where there is a long unloading platform. The contractor extended the rail line around to the east as a temporary construction track.

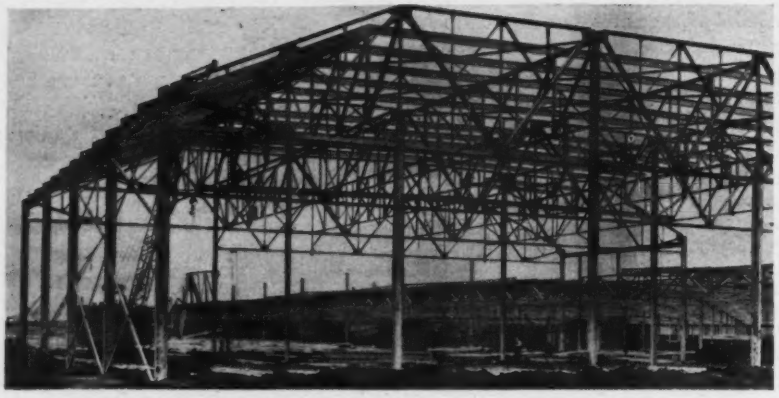
Air conditioning and lighting

While the blackout feature is considered an important point in the design of the plant, the lack of windows is not entirely, nor even basically, a result of blackout requirements. Rather, there was need for uniform temperature throughout the plant, which it is difficult to provide if the walls contain much glazing. Therefore windowless walls, and air conditioning, which, of course, required artificial lighting, were the logical design.

Studies showed that the internal sensible heat in the main building, including that from occupants, lighting, motors, and sun effect on walls and roof, would be 17,919,000 B.t.u. Of this amount, 2,500,000 B.t.u. comes from the lighting system. To offset this internal sensible heat, it was estimated that refrigeration equivalent to production of 2,800 tons of ice per day would be required, to be disbursed through the air con-



Texas plane plant, windowless and air conditioned, includes world's largest industrial room inclosed in cellular steel.



Steel went up in a hurry despite the mud. This is a view of the high final assembly bay across the north side of the main building.

ditioning system. Four 700-ton freon compressors were installed for the air cooling.

Some of the process and store rooms along the south side of the main building are not directly air conditioned, but depend upon air leakage from the main room. This leaves a volume of 16,170,000 cu.ft. to be air conditioned in the main plant. Nine air conditioning units, having a combined capacity of 1,300,000 cfm., were placed in the main room near the roof. These units are enclosed on all sides and bottom, but open to the atmosphere through glazed enclosures. Because the units are enclosed, no light will show through the glazing. Each unit contains two 7,200-cfm. blowers, air cleaners and filters. Heat, when required, is supplied to the units by steam from the powerhouse.

Lighting is based on the installation at the Allison plant in Indianapolis, used by General Motors as a fluorescent lighting laboratory. There the lights were first placed to produce 45 ft.-candles at bench level, but studies and experiments ultimately reduced the lighting strength to 26 ft.-candles at this level, now regarded as ample and correct except for precision operations. Therefore the North American plant lighting is designed on the 26 ft.-candle basis.

Light in the main building is supplied by 7,000 fluorescent units, hung 12 ft. above the floor. Each unit consists of three reactors, three condensers, and three 40-watt daylight-type fluorescent tubes 40 in. long, all mounted in a porcelain reflector. This lighting gives 92 percent of natural north light at midday.

Fast construction

Construction started last Nov. 13. Despite 34 days of rain, in which 14.2 in. of rain fell, 103 days later saw the main building erected and inclosed, and work well along on the smaller buildings. Equipment for the manufacturing processes started rolling in by mid-February, and the plant was ready for operation April 6.

Excavation was simple. Scrapers removed the humus topsoil from the level cotton patch and did what little site grading was necessary. Foundation pedestal pits were dug with crane and clamshells. All concrete came by transit mix from a temporary plant installed near the job. From the very start the contractors battled deep mud. Delivery of material and building supplies was not impaired, because of the temporary railroad spur, but distribution around the job became a problem.

James Stewart & Co., Inc., let the fabrication of the 3,900 tons of structural steel to the Muskogee Iron Works, Muskogee, Okla., and the erection to John Beasley of Muskogee. Trusses were assembled near the railroad spur, and were hauled complete by trucks to crawler erecting cranes. These trucks were literally dragged through the mud by tractors.

As fast as the steelwork got out of the way the ground was smoothed up, covered with gravel and the concrete slab placed. Placing of wall and roof material followed close behind steel erection.

The Stewart contract included all construction except furnishing and installation of plumbing and air conditioning. This work was done under separate contract by Geo. Freyn Bros., Indianapolis. Freyn found it impossible to obtain regular equipment in many cases, so built air conditioning cabinets, vent ducts, heating units, and even metal furniture and parts racks in one of the best-equipped shops ever found on a construction job.

Contractors fought mud at every turn. Here a tractor drags a truckload of steel through the plant site.

Direction

The plant was designed by Allen & Kelley, architects, Indianapolis, and J. Gordon Turnbull, consulting engineer, Cleveland. Mr. Turnbull was engineer in charge of the work. F. H. Shaw was supervising engineer for the Defense Plants Corp. For James Stewart & Co., Inc., Roger Peabody, vice-president of the southwestern office, was project manager, Joseph Cunningham was general superintendent, and J. E. Fry was engineer. Electrical work was sublet to Fischbach & Moore, New York; M. L. Ancil was in charge.

Are Tin Cans Worth Salvaging?

***Contents in Brief**—Many municipal engineers are toying with the idea that tin and iron might be salvaged from the cans collected with refuse. The following analysis made by Arthur D. Little, Inc., leaves small hope that salvage of this kind would be practical or profitable.*

DISCARDED TIN CANS as a source of reclaimed tin have attracted wide attention in the present shipping shortage, but realistic consideration of the problem reveals the difficulties of such a project, according to the *Industrial Bulletin*, published by Arthur D. Little, Inc., of Cambridge, Mass. Cans, with their thin protective layer of tin, are dispersed so widely by users that recovery of the tin in form suitable for reapplication is too expensive for all but the most extreme shortage. No such shortage exists today.

The major difficulty is the collection and delivery of used cans in sufficient quantities to detinning plants at a cost which will permit the detinner a profit. Competent authorities have estimated that two million long tons of tinned sheet iron are used annually in the United States for making tin cans; that at least one million of these tons probably could not be collected at any price, and that the remaining million might be collected by some sort of organized corporation with municipal authorities in the larger urban areas, but that the cost would be problematical.

After collection the cans would have to be shipped to a detinning plant. There are only a few such plants in the United States operating today chiefly upon the clean trimmings and clippings from the can factories and other fabricators of tinned sheet steel. Five of the most important of these plants are located in the metropolitan areas as follows: two in the New York area, one in Pittsburgh, one in Chicago and one in San Francisco. There are a few smaller plants located elsewhere.

Difficulties in salvaging

To recover the tin at the lowest possible cost, says the *Industrial Bulletin*, many more plants would have to be built so as to reduce the cost of transportation of the empty cans. It is estimated that without crushing or baling, a boxcar load of empty cans weighs less than five tons. Manifestly, cans in that condition cannot be shipped very far. If they are crushed and baled they present another problem to the detinner, making it difficult for him to wash and cleanse the cans, a process necessary before detinning because most of the empty cans today, in addition to the remains of contents still adhering, have lacquer coatings, lithographing, paper labels, and plastic sealing materials which must be removed.

Furthermore, the residual steel scrap is of low value. One hundred pounds of tin cans, after the beans, corn or tomatoes have been removed, has at the most 1.3 pounds of tin in it, of which good detinning practice will remove about 1.2 pounds. This leaves about one-tenth of one percent of tin remaining in the detinned sheet steel. The steel manufacturers call this kind of scrap a tramp alloy, and if large tonnages of it are used, tin accumulates in the steel because in steel practice practically none of the tin is lost. Thus they will not pay as high a price for it as they will for clean sheet steel scrap having five-hundredths of one percent or less of tin. One of the difficulties in removing all of the tin from the can is the appreciable amount located in the folded seam where the detinning reagents cannot reach it readily.

Iron content in cans

Many current uses of discarded cans depend on the iron, rather than the tin, content. On some occasions old tin cans have been collected in urban areas, pressed into bales and sent to foundries where they were cast into rough castings such as sash weights. In at least one urban area in the United States today the cans are recovered and shredded after removing all of the organic materials. These shredded cans are then sent to copper mines where the iron is used to remove copper from mine water, ore leachings, and residual copper-bearing liquors. This particular area is located favorably in respect to these mining operations and most, if not all, of the cans from this area find a ready market in the shredded form.

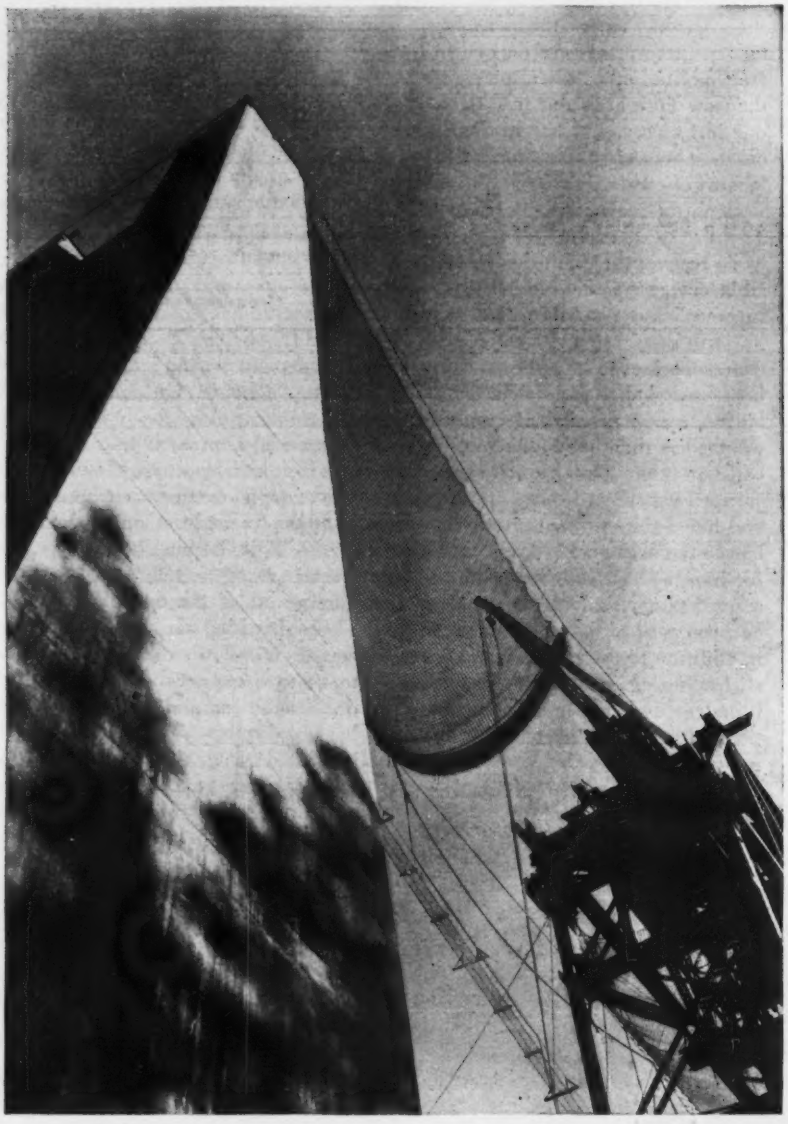
While a theoretical waste of 25,000 tons of tin in tin cans thrown on the dumps, out of our annual consumption of 80,000 tons of tin, seems to be inexcusable, the cost of recovery is so great that private capital would hesitate to undertake the task, according to the *Industrial Bulletin*. If it should be necessary to recover this tin because of interruption of available supplies, it would have to be done at public expense and the cost would be high.

[Editor's Note: *Without prejudice, we call attention to the fact that the Washington Suburban Sanitary Commission at Hyattsville, Md., recently started to salvage tin cans, this practice netting a profit of $7.00 a ton; see* ENR, *Feb. 27, 1941, p. 348.*]

Tin cans separated from the refuse brought to an incinerator plant. Municipal engineers are pondering the salvage possibilities of this waste material.

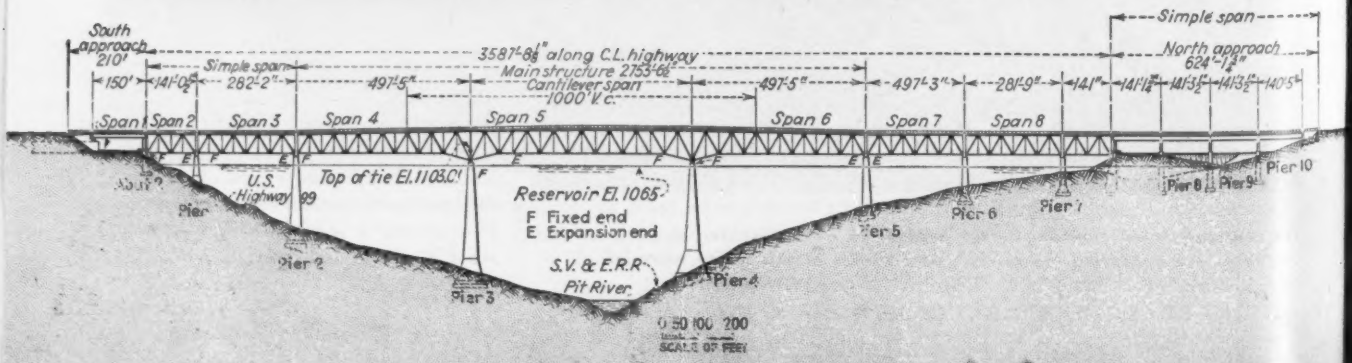
Design Features of the Pit River Bridge

***Contents in Brief**—Concrete piers with a record height of more than 350 ft. are required to carry the double deck, highway and railroad bridge across an arm of the reservoir to be formed by Shasta Dam. Design includes provision for earthquake forces. Reinforcing in the tall piers requires four vertical rows of 2-in. square bars butt-welded for continuity from top to bottom. Volume in pier bases necessitates mass-concrete cooling system.*



Piers of 350-ft. height involved unusual design problems to take care of ordinary loads combined with earthquake stresses.

Type of structure and span lengths were developed from extensive studies of pier and superstructure costs.



RECORD HEIGHT PIERS are the outstanding feature of the Pit River bridge being built by the Bureau of Reclamation as part of the railroad and highway relocation made necessary by the construction of Shasta Dam for the Central Valley Project in California. The bridge is located about 14 miles north of Redding and will carry double tracks of the Southern Pacific Railroad and four lanes for the Pacific highway (U.S. 99) over the Pit River on a double deck structure with main piers about 350 ft. high. Height of the upper deck above the present river level is about 500 ft., but completion of Shasta Dam on the Sacramento River will produce an arm of the reservoir on the Pit River with maximum water level within 38 ft. of rail height on the bottom deck of the bridge.

Construction of the record height piers is nearing completion and steel erection has been started. The present article reviews the general features of the Pit River bridge design. Previous articles in this publication have described the Central Valley project, Shasta Dam, and the 30 miles of railroad relocation, of which this bridge is the most notable structure.

Preliminary studies

Some preliminary studies were made by the California Division of Highways, and more extensive investigations were later made by the Bureau of Reclamation. At the outset it

appeared that a combination bridge, with a lower floor for the railroad and an upper floor for the highway, would be most economical.

In the bureau's studies, different lengths of simple truss spans were tried first, and a preliminary design of the piers and superstructure was made for each span length. From these data the quantities and estimated costs were computed, and the most economical length of span was determined. This information was used directly in determining the lengths of simple truss spans near the ends of the bridge, namely, spans 2, 3, 8, and 9 (see drawing). Although the studies indicated that spans 3, 7, and 8 should be of slightly different lengths, they were made the same length in order to save on the cost of fabrication. Likewise, spans 2 and 9 were made the same.

In the central portion of the bridge between piers 2 and 5, it seemed evident that three spans should be used. Studies were made for three different cantilever structures, having various ratios of length of central span to length of anchor span. When the cantilever studies, which included cost estimates of substructure and superstructure, were completed, the most economical design was found to be the one having a central span approximately 25 percent longer than the anchor span. The suspended span (span 5) was made 447 ft. long. Although it should be somewhat shorter for economy, this length was used because it gave the best arrangement of panels in the main span.

Also, economic studies were made on two two-span continuous trusses and one three-span continuous truss. The continuous structures, however, all proved to be less economical than the most economical cantilever, largely because the cost of the substructure was greater. In the continuous type, the entire horizontal force in a direction parallel to the bridge has to be taken by one pier, whereas it can be taken by two piers in the cantilever type.

Deck girder spans were found to be most suitable for the highway approaches. The south approach has one span, 150 ft. long, and the north approach has four, each 140 ft. long.

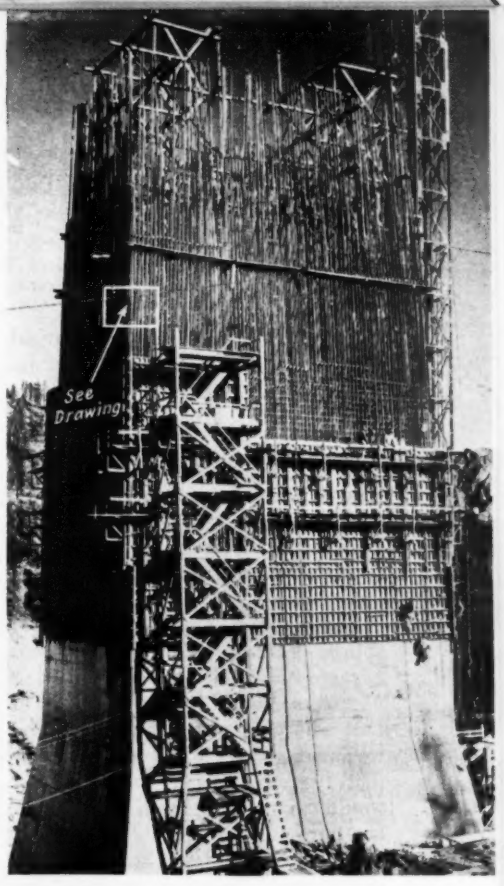
Substructure problems

As far as is known, the piers of the Pit River bridge will be the highest in the world. Towering more than 350 ft. above the ground, the two central piers are each taller than a thirty-story office building. The design of the piers presented unusual problems of large magnitude and variety. As the larger piers will be almost completely submerged, it was decided to consider full hydrostatic uplift acting on them. The design was further complicated by the fact that the piers must resist earthquake forces, because the bridge site is located in an earthquake zone.

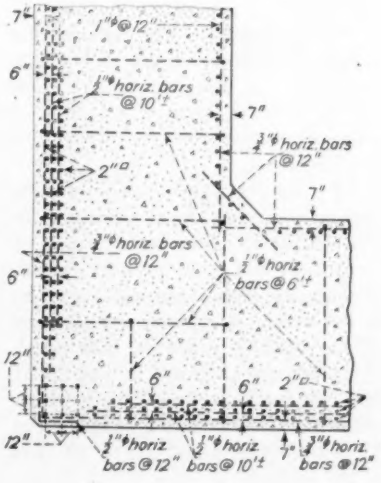
As there were no similar structures in existence that were submerged to such a great depth, a basis for design was obtained from extensive mathematical analyses and shaking table investigations made in the Denver office of the Bureau. These studies are described in an article "Earthquake Studies for the Pit River Bridge" by J. L. Savage—*Civil Engineering*, August 1939.

In the investigations, actual earthquake intensities equivalent to measured intensities during the Long Beach earthquake (Mar. 10, 1933), and the Helena, Mont., earthquake (Oct. 31, 1935) were applied to the piers. When these earthquake intensities were applied as steady forces, the resultant of all forces fell outside the base, indicating that the pier would overturn. But further investigations showed that the lateral movement of the foundation tending to tip the pier would reverse itself before the mass of the pier could follow such movement. The pier would therefore not overturn, but would merely rock slightly on its base. An experiment, in which a model of one of the piers was placed on a shaking table, confirmed the mathematical analyses. Incidentally, the results of these investigations probably explain why many bridge piers and similar structures did not fail during the Long Beach and Helena quakes.

In the actual design of the piers, horizontal earthquake forces were considered on the railroad live load, on the superstructure, and on the pier itself. In addition, earthquake forces on the water were also considered. These were first calculated according to the principle of virtual mass; then the forces actually used in the design were obtained by multiplying the computed forces by proper factors that allow for friction and skin effect; the factors were determined in a pendulum experiment in which a pier model was suspended in water.



A forest of 2-in. square reinforcing bars were required for the record height concrete piers. Arrangement of this steel is indicated in the drawing.



Briefly, there were three main steps in the design of each pier:

(1) Designing the base so that there will be little or no uplift when the pier is subjected to the most severe combination of normal forces, including full hydrostatic uplift, traction or braking force, wind, and sway of locomotive.

(2) Computing the intensity of earthquake that will bring the resultant of all forces to the edge of the base; or in other words the intensity of earthquake that will just cause the pier to tip on the edge of the base. This intensity, which is expressed

as a fraction of the acceleration due to gravity, is computed for different combinations of earthquake loads and wind loads. However, in no cases were intensities of more than 20 percent of gravity used in the design.

(3) Designing the shaft so that it will resist the greatest combination of earthquake loads and wind loads.

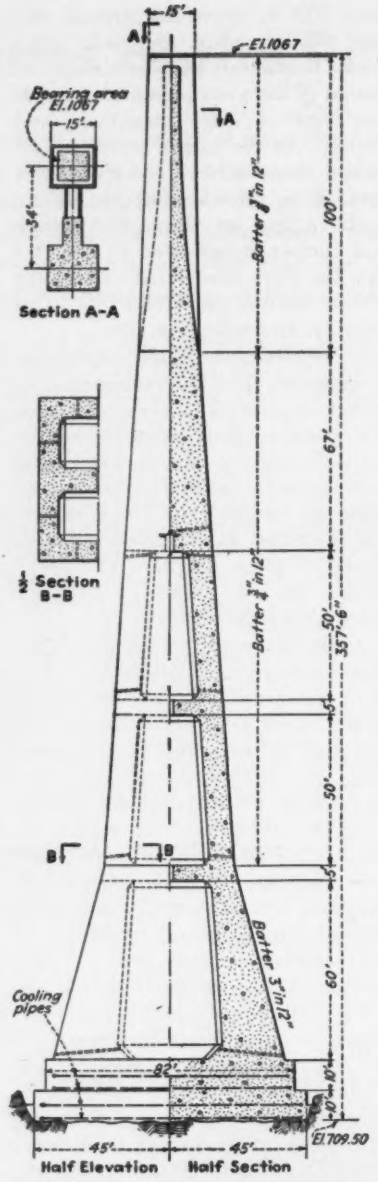
In the larger piers, the vertical reinforcement consisted of 2-in. square bars. Four rows of these were needed in the broad face near the base of the shaft pier 4 and three rows in the corresponding face of pier 3. The distance between rows, center to center of bars, was made 6 in., and the spacing of the bars in each row was made not less than 7½ in.

Lapping the 2-in. square bars at splices seemed out of the question, because of difficulty in securing necessary bond. It was decided to butt-weld the ends of the bars. The welds are staggered in such a manner that the steel at any cross section would be reduced by no more than one-third if the welds should fail.

To save concrete, cell compartments were provided in the large piers 3 and 4. These compartments resulted in saving of 4,600 cu.yd. in pier 3 and 3,600 cu.yd. in pier 4. Suitable inlet pipes and vents permit the compartments to fill with water.

An investigation was made of the torsional stresses in the pier shafts produced by the transverse wind forces, but the stresses were not of sufficient magnitude to require special reinforcement.

All piers are founded on solid rock, and it was considered desirable to cool artificially the large bases of piers 2, 3, and 4, to prevent shrinkage cracks from forming near the rock contact. A typical arrangement of the cooling pipes is illustrated. The pipes are arranged in a series of 5-ft. lifts, and the time during which water is to be circulated ranges from 35 days in the lowest lift to 10 days in the highest.



Volume of concrete in the large pier bases required the use of a cooling system.

Superstructure design

After the span lengths and general type of structure were determined from preliminary economic studies, the panel lengths and truss depths were established. The trusses are 34 ft. apart, and the depth, center to center of chords, varies from 57 ft. in the simple spans to 87 ft. in the cantilever at piers 3 and 4, where a greater depth is more economical.

The railroad and the lower truss chord of the bridge, except for the breaks at piers 3 and 4, are on a 0.4-percent grade. In the simple spans and in the suspended span at the center of the bridge, the top and bottom chords are parallel; but in the cantilever portions of the structure, the chords are not parallel, to provide greater depth for the trusses of the main span. Thus the top chord slopes upward relative to the bottom chord from pier 2 to the expansion end of the suspended span, and similarly the top chord slopes downward from the fixed end of the suspended span to pier 5. The depth of the trusses could not be increased by making the bottom chord lower, because the lower portions of the trusses would be below the water surface.

Studies showed that the most economical panel length was 35 ft., but the length could be varied considerably without causing an appreciable increase in the cost. Actually, a panel length of 34 ft. 8 in. is used in the simple spans and in the larger portion of the anchor arms. Where the depth of the trusses is greater, a 39-ft. 4½-in. panel length is used to give a better appearance.

In general, A.R.E.A. specifications for steel railroad bridges (1938) and A.A.S.H.O. standard specifications (1935) were followed. Tension member design included a basic unit stress of 18,000 lb. per sq.in. for carbon steel and a corresponding stress of 24,000 lb. for silicon steel. For compression members the basic unit stress was reduced according to the formulas given in A.R.E.A. specifications.

Six different combinations of loading were used in computing total stresses in the truss members; and for each combination, the basis unit stress was multiplied by an appropriate factor. Each member was designed for the combination of loads requiring the heaviest section. The various combinations are shown in the following tabulation, where the numbers in parentheses are the factors by which the basic unit stress is multiplied:

Case I	$D+L+I+H+C$	(1.00)
Case II	$D+L+I+H+C+T+W$	(1.25)
Case III	$D+1.5(L+I+H+C)$	(1.33)
Case IV	$D+L+I+H+C+T+E$	(1.50)
Case V	$D+L+I+H+C+T+E+S$	(1.75)
Case VI	*Erection* R	(1.25)
	RW	(1.50)

In this notation,

D = Dead load.
L = Railroad live load.
I = Railroad impact.
H = Highway live load and impact.
C = Centrifugal force.
W = Wind and sway.
T = Tractive force or braking force.
E = Earthquake force.
S = Secondary stresses.
R = Erection stresses.
RW = Erection plus wind stresses.

The superstructure was designed

for E-72 railroad loading and H-20 highway loading. When the railroad live load was considered on two tracks, 90 percent of E-72 loading was used on each track; and when railroad live load was considered in combination with highway live load, only 85 percent of the E-72 loading was considered on each track.

The earthquake force acting on the superstructure was taken as 10 percent of the dead load and 50 percent of the live load without impact. It was considered as acting in any direction. Full wind forces were assumed as acting perpendicular to the bridge, or 71 percent of these forces were considered as acting parallel to the bridge.

All truss members are built of plates and angles with the angles turned in. Silicon steel is used in all the trusses except in those of the relatively short 140-ft. spans.

In the computation of temperature stresses, a temperature range of 60 deg. F., plus or minus, was considered. The greatest movement in the bridge occurs at the expansion bearing of the suspended span. Here, it is estimated that the combined movement due to temperature and deformation may amount to as much as 5½ in. in either direction. To reduce friction and wear, bronze bushings are used for the pins of the hangers on the suspended span.

One of the interesting features of the bridge is the extensive use of perforated plates. The perforations are elliptical-shaped holes spaced at approximately 4-ft. center to center. Large enough for a man to enter, these holes provide access to the interior of the member for riveting. The perforated plates are used in place of lacing, because the heavy lacing required for the large truss members would be difficult to connect.

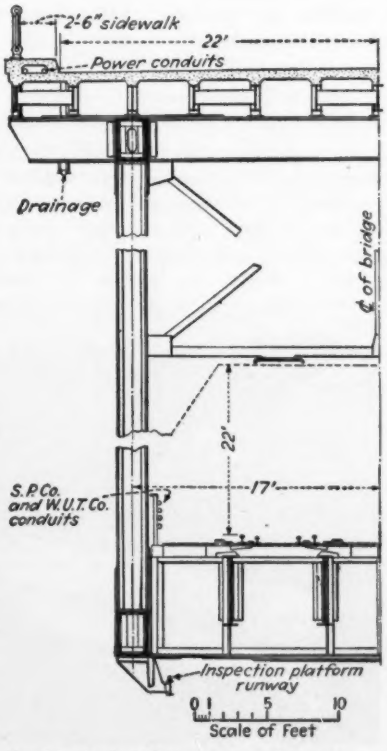
As little was known about the effectiveness of the perforated plates, tests were made on celluloid models of: (1) four perforated plates, each having a different size hole, (2) a laced section, and (3) a solid plate. The rigidity of each model relative to the solid plate was determined by applying direct stress, moment, and shear to the models, and then measuring the deflections. In addition to these tests, photo-elastic tests were made on bakelite models of the four perforated plates to determine the magnitude and distribution of stress in the vicinity of the holes.

Results from all the tests showed that the plate having a hole 2 ft. 3 in. long and 14 in. wide was the most satisfactory. The tests further showed that it is safe to consider the net area as effective in taking direct stress.

Lateral bracing between the top chords is the same depth as the chords. The web of a rolled beam is split in the middle, and each half is used as a flange for the bracing. The flanges are laced together by small tee-sections welded to the webs. Lateral bracing between the bottom chords consists of rolled beams or sections built up of pairs of angles.

In the railroad deck the floor beams and stringers are plate girders of silicon steel. An interesting feature of the railroad deck is the type of expansion bearing used for the stringers at the expansion end of the suspended span. This bearing is a semi-circular steel casting having a radius of 7½ in. and a length of 15 in.; the flat side is the bearing area which supports the end of the stringer. The casting is suspended by a 1½-inch U-shaped annealed plate which is attached to the floor beam.

In the highway deck, the floor beams are built-up girders or rolled beams. The stringers are rolled beams. Silicon steel is used for the floor beams and carbon steel for the stringers.



Double-deck design for railroad and major highway crossing of Pit River.

Movement in the top chords causes movement of the attached floor beams; and, as a result, the stringers exert horizontal forces on the floor beams. To keep these horizontal forces from becoming too high, the stringers were made continuous for not more than four panels. Sliding joints, which are provided at the ends of the stringers, are located at points 4 ft. away from the floor beams, as these points are not far from the inflection points of the stringer spans (panel lengths).

The 6½-in. roadway slab is supported on the stringers. One-inch transverse joints in the slab are located directly above the sliding joints of the stringers, and are made watertight by the use of dumbell-shaped rubber seals. In addition to these, larger expansion joints in the form of finger castings are located directly over the expansion bearings of the trusses.

The 44-ft. roadway is flanked on each side by a 2½-ft. sidewalk. Full superelevation is used on the curved approaches at the ends of the bridge, gradually changing to the typical section over the bridge by means of 500-ft. transition curves. The increase in the depth of the trusses at the center of the bridge necessitates a hump in the highway profile. Over this hump are three long smooth vertical highway curves which are laid out so as not to limit unduly the sight distance.

Miscellaneous features

Water from the highway deck is carried in gutters to drain inlets which consist of ¾-in. square bars arranged in the form of grills, 6¾ in. wide by 15 in. long. Vertical riser pipes connect the drain inlets to longitudinal drain pipes which are suspended from the highway deck. From the lowest points of the longitudinal drains the water flows into large vertical pipes which empty into the reservoir. A total of 115,000 lb. of metal is used in the drainage system.

To aid in inspection, three movable platforms are to be constructed underneath the bridge. Each platform is carried by a car which runs on two rails, one suspended from each of the lower chords of the trusses. The track

is continuous except for the breaks in the lower chords at piers 3 and 4 where walkways are to be constructed between these breaks of track. The cars, which are approximately 14 ft. long and 6 ft. wide, are hand-propelled. In addition to being used for inspection, the cars and platforms will also facilitate painting and other maintenance work.

Contract awards

The contract for the piers and abutments were awarded Oct. 5, 1939, to the Union Paving Co., San Francisco. The bid of $1,138,288 was the lowest of ten received. Principal items in this contract are the placing of 94,000 cu. yd. of concrete and 10,930,000 lb. of reinforcement bars.

Bids for the fabrication and erection of the superstructure were opened Jan. 16, 1940, in the Sacramento office of the Bureau of Reclamation. The American Bridge Co. bid of $2,588,354 was the lowest of two received. The contract calls for 34,220,000 lb. of structural steel. Of this amount, approximately 57 percent is silicon steel and the remainder is carbon steel.

Organization

The plans and designs for the Pit River bridge were prepared in the Denver office of the Bureau of Reclamation under the direction of the bureau's bridge engineer, Robert Sailer, working under the supervision of H. R. McBirney, senior engineer in charge of the canals division. Glenn B. Woodruff was engaged for general consultation. The executive and engineering work of the Bureau is under the direction of S. O. Harper, chief engineer; Walker R. Young, assistant chief engineer, and J. L. Savage, chief designing engineer.

Construction of the bridge is being supervised by the field forces of the Bureau of Reclamation. R. S. Calland is acting supervising engineer for the Central Valley Project and Ralph Lowry is construction engineer of the Kennett Division, with headquarters at Redding, Calif.

All administrative work of the Bureau is under the supervision of John C. Page, Commissioner, with headquarters in Washington, D. C. The Bureau of Reclamation is in the Department of the Interior, Harold L. Ickes, secretary.

Laying a Deep Intake in Lake Michigan

***Contents in Brief**—Part of the new $1,200,000 waterworks project for Muskegon Heights is a mile-long steel intake into Lake Michigan. The pipe arrived on the job in 120-ft. lengths and was laid by dredge crane from scows in deep trenches with the joints made up by divers.*

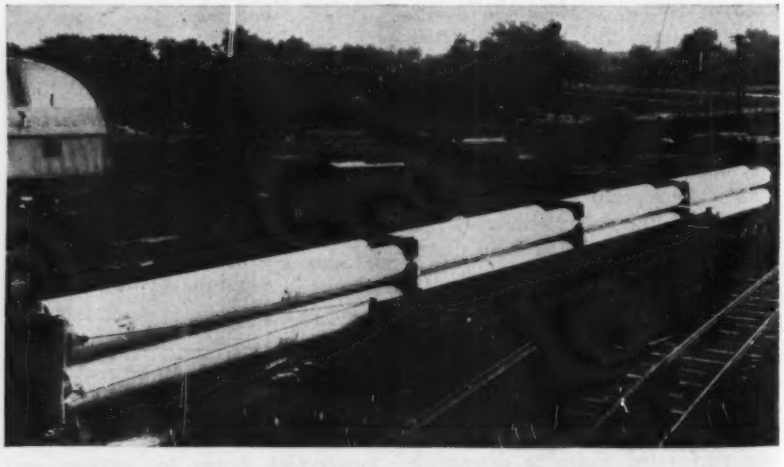
LONG LENGTHS of 30-in. steel pipe for the new water intake for Muskegon Heights, Mich., were laid speedily in Lake Michigan by means of a revolving crane on a dredge scow. This 4,620-ft. intake is the new source of water supply and a part of the city's new $1,200,000 waterworks improvements project comprising low and high lift pumping stations, pipelines, filtration plant and reservoirs. The intake is financed by city funds alone while the remainder is being built under WPA aid and regulations. It has a capacity of 15 mgd. sufficient to provide for an estimated 1980 population of 36,500 people. The capacity also will permit a maximum hourly consumption of 410 gal. per capita daily.

Fabrication and delivery

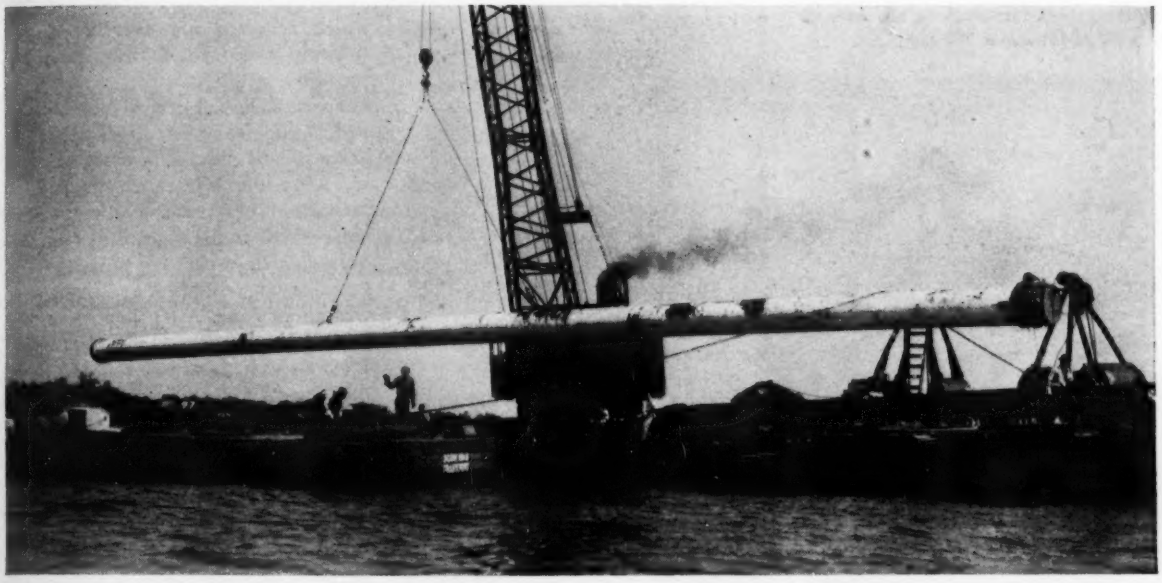
Except for eight 60-ft. lengths adjacent to shore, where a deep cut, rough surf and shifting sand bottom made it desirable to use short lengths, 120-ft. lengths were called for. Standard sections were 60 ft. long and $\frac{5}{8}$ in. thick, the longitudinal seam and girth joints being butt-welded by the shielded arc process. After being tested hydrostatically to 200 psi., the surface of each section was cleaned, grit-blasted and enameled with a special coal tar pitch inside and out by a pipe-coating machine. Two standard 60-ft. lengths were welded together in the shop and shipped in 120-ft. lengths. Four pipes were shipped at a time, requiring one railroad gondola car and two flat cars.

To facilitate the handling of the pipe two lifting lugs spaced 30 ft. apart or 15 ft. either side of the center were welded to the pipe on a plane perpendicular to the horizontal plane of the pair of harness lugs located at each end of the pipe. In addition to easing the handling and saving time the lifting lugs help avoid damage to the outside coating. They also insure the pipe being held in exact position for the installation of the harness bolts in the trench.

Each shipment of pipe was spotted on a siding alongside a dock accessible to the contractor's floating equip-



Four 120-ft.-length pipes were shipped to the job on three cars.



Lifting a 120-ft. length of 30-in. steel pipe for laying in the trench excavated in the lake bottom.

ment. The pipe was lifted off the railway cars and loaded on the dredge or separate scow to be transported to a storage yard located along the government channel between Lake Michigan and Muskegon Lake. Sandbags instead of wood blocking were used in order to minimize damage to the coating. As the pipes were needed for laying they are again loaded on a scow, usually two at a time, when the dredge equipment was brought back to the dock for refueling or to escape a rough sea.

Equipment employed

A 45-ton full revolving steel frame crane, equipped with an 85-ft. boom, was used for all excavation, backfilling, handling and laying of pipe. This stationary crane was fastened down to one end of a 34 x 110-ft. scow. Three large timber anchorage spuds were employed to good advantage for this work due to the ease of maneuverability. The dredge equipment was moved to and from the dock, which is located 3.5 miles from the pipeline, by means of a tug. Once spotted on the job the dredge scow was readily moved into any desired position by means of a 90-hp. launch.

A smaller size tug was used for towing the pipe on a scow from the yards to a point alongside the dredge. It also transported workmen and materials. A complete set of tools, pumps, welding and torch burning equipment, spare parts, electric lighting equipment and diving equipment were kept on the dredge scow so that all minor repairs could be made on the job.

Two crews of workmen, eight men during the day and five at night working on 12-hr. shifts, permitted operations to be carried on continuously. Because of the short season for lake work and in order to complete the job on time, work was also carried on during Sundays.

Excavation methods

The depth of cuts from lake bottom to invert of the pipeline varied from 13 to 20 ft. for 2,200 ft. out from shore and closely followed a depth of 9 ft. for the outer 2,400 ft. of line, where the pipe grade closely parallels the lake bottom. Excavation consisted largely of beach sand, readily removed with a clamshell bucket. The dredge was spotted so that spoil material could be cast 60 to 75 ft. either side of the trench. Except for the deeper cuts the bucket was always lowered on the center of the trench for clamming out the material. As near as could be determined from diving observation, the banks took an average slope of 1.5:1. On occasions it was observed that the bottom sides of the trench stood nearly vertical, the material in these areas being firmly compacted.

After each pipe was laid backfill was placed over the area of the center of the pipe to secure it in position. In general it was found best to fill only to the top of the pipe as any further material created trouble in keeping the end of the pipe clear for making up the next joint.

Laying the pipe

The line of the pipe was established by a marker on shore and markers on crossarms of wood piles driven along the pipeline at 600-ft. intervals. A grade pole, made of wood and steel shaped to fit over the top half of the pipe with a 1-in. graduated pipe pole attached, was used for setting the crown of the pipe to grade. At the same time that part of the pole projecting above the water was sighted on the range markers for line.

The crane sling cable was utilized to determine if the pole was plumb, and also for sighting the pipe on line. All grade readings were taken from the water level, the elevation of which was determined from a gage board set at mean lake level, on the nearest pile supporting a range marker. The location of the dredge was accurately spotted at all times by means of a marked tag line cable attached to the pile marker.

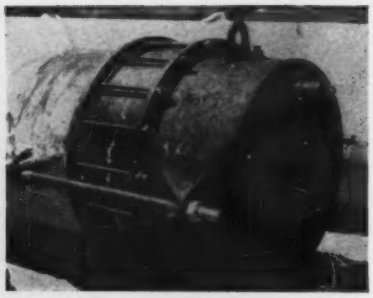
All the pipe joints were made by means of mechanical couplings with $\frac{9}{16}$ by 10-in. middle rings, $\frac{3}{8}$-in. follower bars, $\frac{5}{8}$ by $1\frac{5}{8}$-in. grade 27 gaskets, and eighteen $\frac{3}{4}$-in. cadmium-plated bolts. One pair of $1\frac{1}{4}$-in. cadmium-plated steel studs, $39\frac{1}{2}$ in. long, together with four cast lugs welded to the pipe, were utilized for harness assemblies. The makeup clearance

Applying coal tar pitch to the outside of pipe following a 200-psi. test.

between the outside diameter of the steel pipe and the inside diameter of the coupling rings was $\frac{3}{16}$ in. and for this reason it was necessary that the ends of the steel pipe conform practically to true circles.

Just prior to lowering the pipe into the trench (see illustration) the diver removed the 8-in. (thick) wood bulkhead, which was temporarily secured on the end of the pipe last laid by means of the pair of harness bolts. At the same time the diver made an inspection of the area around the pipe joint to be sure that all material was properly excavated to allow room for entering the pipe and drawing up the coupling bolts. Before lowering a length of pipe a rubber gasket and follower ring was slipped over the end abutting the pipe already laid; and on the other or outer end were attached the follower ring, gasket, middle ring and temporary wooden bulkhead. The harness bolt fastening nuts were slacked off the wooden bulkhead in order to allow the escape of entrapped air which accumulated during the lowering process.

The pipe, weighing 12 tons, was picked off the scow by the dredge crane and lowered into the trench to a point 2 ft. above grade prior to the diver's descent. By means of telephone communication between the diver and the tender or signal man it was possible to enter the end of the pipe in the sleeve coupling with about



Test plug secured with harness bolts and mechanical coupling.

the same exactness and ease as if the pipe were laid in the open. Normally not over 10 min. time was required for entering the pipe. As soon as the pipe was entered the harness bolts were installed and at the same time a clearance of $\frac{3}{4}$ in. was established between the ends of the two pipes by measuring with a spreader rod between the harness lugs. The next step involved setting the outer end of the pipe to line and grade and then sandbagging it. Before releasing the cable strain from the pipe the center was also sandbagged.

The diver then went back to the joint to check the pipe clearance and install the eighteen coupling bolts, which required not over an hour's time. In order not to introduce any excessive stresses in the pipe due to temperature changes of the water, which may vary by 40 deg. F., the harness bolt nuts were slacked off $\frac{1}{4}$ in. After the joint was finished an inspection was made by the owner's engineer. The average total time required for lowering the pipe in place, sandbagging, coupling and inspection was about 5 hr. After each pipe was laid it was immediately spot backfilled to a little above the crown of the pipe in order to secure it in position.

Organization

The waterworks improvement project was built under the direction of George F. Liddle, superintendent for the city of Muskegon Heights. Ivan Cole was the job superintendent for the Luedtke Engineering Co., contractor. The pipe was fabricated in the Chicago shops of the Chicago Bridge & Iron Co. The Gurlick & Henderson Co., Inc., inspected it. The intake line was designed by Greeley & Hansen, consulting engineers, who were retained for supervision of construction, being represented by Frank E. Fulmer.

Paving Financed by Revolving Fund

A THREE-YEAR PROGRAM of paving improvement at Kokomo, Ind., began in 1939, with merchants proposing to finance the construction of new sidewalks in front of their stores, for which the city engineering department gave an estimate of 25 cents per sq. ft., or $3 per lin. ft. for walks 12 ft. wide. Later, however, advantage was taken of an offer by the WPA to extend the improvement at small additional cost to include 15-ft. sidewalks, concrete street paving and combination curb and gutter.

As stated by Lindell D. Hale, city engineer of Kokomo, in *Concrete Highways* (bulletin of the Portland Cement Association, Mar.–April, 1941) the WPA supplied approximately 12 percent of the materials, and all the labor, while the city furnished equipment and supervision. Owners of benefited property contributed $4 per lin. ft. for the rest of the materials. The paving work also resulted in considerable improvement of appearance in the business district, many new store fronts being put in. Public utility services were put in by the utility concerns prior to the paving.

As an interesting feature in the financing of the project, Mr. Hale notes that in financing their share of the cost, the merchants in a block at first formed an association for the purpose of collecting the $4 per front foot before the work was started or while it proceeded. But later, the State Board of Accounts informed the city that a 1939 bond issue of $150,000 for street and sewer improvements could be used as a revolving fund to finance the concrete street program. This arrangement enables the city to start a paving project with revolving-fund money, and the property owners then reimburse the fund after completion of the work.

Why the Tacoma Narrows Bridge Failed

***Contents in Brief**—Report of Federal consultants finds members of the structure showed remarkable strength; towers severely damaged; aerodynamic instability responsible for torsional motions; torsion, to which width gives important resistance, is a greater danger than is lateral deflection; greater attention to structural damping desirable.*

A COMPREHENSIVE REPORT based on "a complete investigation of the design, the behavior after completion and the failure" of the Tacoma Narrows Bridge, "the most notable failure in the history of bridge building since that of the Quebec Bridge," has been prepared by O. H. Ammann, Theodore von Kármán and Glenn B. Woodruff, acting as a board appointed for this purpose by John M. Carmody, Federal Works Administrator. Findings of the board emphasize the extreme flexibility of the structure and point out that lateral deflections as the result of wind on this bridge (and on other long suspension bridges) are of much less consequence than are the torsional movements made possible by the combination of narrow width and small vertical rigidity. Widespread attention that is now being given to the stability of suspension bridges is sure to increase the sum total of knowledge, the report states, but present knowledge, expertly applied, is already sufficient to permit safe design of long, slender spans.

In the analysis made by this board, recent wind tunnel tests were considered and numerous calculations and comparisons were made. Particular attention was given to flexibility and resistance of the structure to torsional motion. The board sees little advantage in fairing, emphasizes the need for rigidity as expressed by the respective moments of inertia in both vertical and horizontal planes, and points out the advantages of weight. Resistance to dynamic forces, the report says, must be considered in terms of dynamics, which makes it necessary to take into account the structural damping in the system. The following has been taken from the report, which is a volume of 290 pages with 62 illustrations and drawings.

The report records the vertical and torsional oscillations of the bridge and the progress of the failure. By analyzing the records of the vertical oscillations the relations between their frequencies and wind velocities shown by Fig. 1 were developed. For each frequency there was a considerable range of velocities, the points plotted being the average of all observations for each frequency. A mathematical analysis of the natural periods of the patterns of the various modes is given. Both the periods and the patterns correspond very closely to those observed on the bridge and also on the models. It was observed that, frequently, the side and center spans were oscillating quite independently of each other.

Behavior of the bridge

In describing the events shortly previous to and during the failure, emphasis is laid on the slipping of the north cable band at midspan and also on the large deflections of the towers. This description also develops the previously unreported fact that there were some deviations from the single noded torsional motions.

As to the condition of portions of the structure that remained: anchorages and piers show only local damage. The tower shafts have buckles in the cover plates (shoreward sides) throughout their entire height, indicating stresses beyond the yield point; some yielding in adjacent parts is also probable. The channelward sections were stressed beyond their yield point, and at least the splices yielded allowing joints to open. The top struts failed at center points. At the center of the north cable about 500 wires were cut by the chafing of the cable band to which the diagonal ties to the stiffening girders were attached. At the southwest hold-down point, at the end of the west side span, the cable was thrown off the saddle. Although not evident from surface inspection, the cables were severely overstressed, possibly to the point of incipient failure. Stiffening girders in the side spans buckled beyond repair at some points and stringers and laterals failed by buckling.

The damping devices installed on the bridge evidently checked longitudinal motions of the floor but had little effect in reducing the vertical oscillations. Stays at the center of main cables may be expected to be effective only for very moderate deformations of the cables. Such central stays when properly designed, exercise a limited effect on vertical oscillations but when loose they are largely ineffective and may become a source of danger when the motions of the cables become large. They were effective in preventing torsional motions, but when one center stay became ineffective (center of span, north cable) it not only rendered the structure more sensitive to torsional motions, but actually induced them by creating a torsional moment. Observations indicated that the change from the moderate parallel motions of the cable to the more violent out-of-phase motions "was almost

MAJOR SUBDIVISIONS OF THE REPORT

Chapter 1—Historical
Chapter 2—Review of design
Chapter 3—Comparison with other suspension bridges
Chapter 4—Aerodynamic forces and resulting oscillations
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Appendix 1—Bibliography
Appendix 2—Moisseiff's preliminary report on design
Appendix 3—PWA's procedure on passing on engineering features of projects
Appendix 4—Review by T. L. Condron (RFC advisor)
Appendix 5—Statements of witnesses to the collapse
Appendix 6—Mathematical analyses of suspension bridge vibrations
Appendix 7—Studies made on models at Univ. of Washington
Appendix 8—Wind tunnel tests made at Calif. Institute of Technology
Appendix 9—Observed deflections of the Golden Gate Bridge

sudden." Tie-down ropes in the side spans probably had some effect in restricting vertical movements of those spans. Since the center span motions were largely independent of the side spans, the effect of these tie-downs on oscillations of the center span was not appreciable. The effects of the hydraulic buffers installed at the towers was probably negligible.

Review of design

"The behavior of the Tacoma Narrows Bridge during the hour before the final failure of its center span was a severe test of the strength of the structure as a whole, as well as of its major component parts. Under the violent dynamic motions and during the final failure, certain parts of the floor structure, the suspenders, the cables and the towers were subjected to stresses far beyond the safe limits for which these parts were designed, and at many points to stresses under which failure had to result. That under these severe stresses the main carrying members, in particular the towers, did not actually fail attests to the excellence of their design, quality of materials and workmanship and to the ample margin of safety which the structure would have had except for the severe dynamic motions."

Although its review was based on an assumed live load of 1,500 lb. per linear foot of bridge, in place of the 1,000 lb. used in the design, the board found that, considering static loads only, all stresses were within safe limits. Calculations with the live load in a position to produce the maximum torsion indicated the extreme flexibility of the bridge in this respect.

Calculations of stresses made on the basis of observed amplitudes during the torsional oscillations of the structure show that, where failure or permanent local damage occurred, stresses had reached the yield strength of the composite members. This indicates that neither faulty design nor defective material or workmanship was a factor in the failure. Under the alternating 45-deg. torsion of the floor, torsional shearing stresses in the concrete exceeded ultimate strength; this explains concrete floor breaks near the center of the span where maximum stress would be expected. Similarly, the wind truss was subjected to the most severe stresses near the center of the span, and this is where the first buckling of girders and failure of laterals was observed.

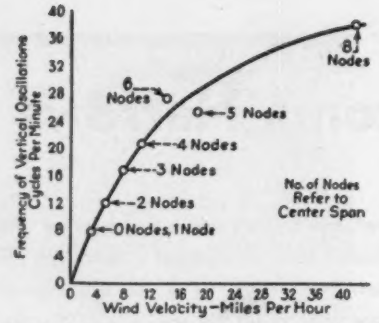


Fig. 1. Relation of frequency of vertical oscillations and wind velocities.

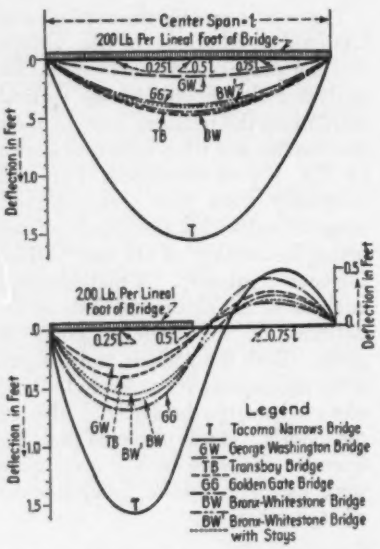


Fig. 2. Comparative vertical rigidity of five long suspension bridges.

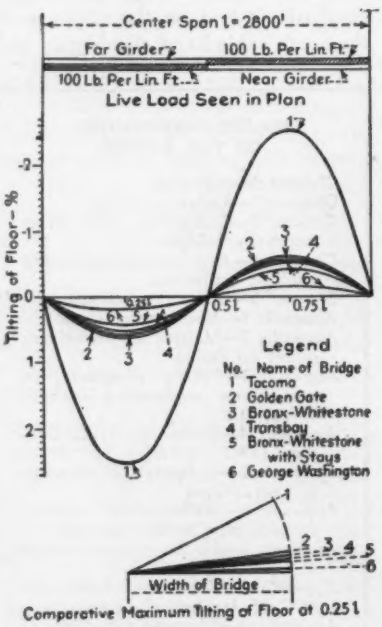


Fig. 3. Comparative torsional rigidity of five long suspension bridges.

Maximum stresses in the side spans occurred when a portion of the center span dropped, allowing the side spans to sag 60 ft. at their centers, six times the maximum calculated deflection. Bending stresses in the cables at the tops of the towers together with the axial stresses were much higher than safe design stresses. It is not certain that incipient failure was not produced.

Stresses in the towers also reached their maximum when, as a result of the dropping of most of the center span, shoreward deflection at the tower tops was about 27 ft., 12 times the maximum calculated. Thus, yield strength was exceeded on both compression and tension sides of the tower shafts. Tension splices failed, probably by shearing deformations of the rivet shanks. Twisting about the vertical axes of the towers caused permanent deformation in the top struts between the two tower shafts.

Comparison with other bridges

The behavior and final failure of the bridge can be explained only by its responses to aerodynamic forces. A complete analysis of these forces and of the response of a suspension bridge thereto is not possible with present knowledge; further observations, experiments and mathematical analysis are required. A comparison between the Tacoma Narrows Bridge and other long span suspension bridges, in the accompanying table, on the basis of their deflections under static load, partially explains the excessive motions of the Tacoma Narrows Bridge and also why aerodynamic forces do not cause motions of similar extent in the other bridges. Two of the other bridges; Golden Gate and Bronx-Whitestone, have relatively flexible stiffening girders, or trusses, and both have experienced to a mild degree vertical oscillations similar to those at Tacoma. At the bottom of the table are given the relative resistances of these five bridges to vertical and torsional motions. These are also shown by Figs. 2 and 3. Three shorter bridges which have shown similar motions were not included in the comparison since they would not explain the "behavior of a suspension bridge 3½ times longer and 6 times heavier."

Experience with early suspension bridges indicated the danger of extreme flexibility, and as a result greater stiffness had become standard

before the end of the last century. Then came a tendency to excessively deep and rigid stiffening trusses, ignoring the fact that weight has an important influence on rigidity. Later the value of weight and the stiffening effect of the cables were appreciated and less rigidity was provided in the stiffening trusses, the extreme in this direction being the George Washington Bridge with no stiffening trusses. Now it appears that resistance against dynamic forces must be considered to attain a well-balanced design.

The fundamental weakness of the Tacoma Narrows Bridge was its great flexibility, vertically and in torsion. The comparatively narrow width gave adequate lateral rigidity but combined with the extreme vertical flexibility, the narrowness made the structure extremely sensitive to torsional motions created by aerodynamic torsional forces.

"The principal elements which influence vertical deflections are weight, cable sag, stiffening girders, towers and side spans. Torsional deformations are influenced by the vertical deflections, hence, by all the above-mentioned elements, and by the width between the cables. Weight not needed to meet the design requirements is, however, an expensive way to supply additional rigidity. To bring its comparative vertical rigidity within the range of the Golden Gate and Whitestone Bridges would require that the Tacoma Narrows Bridge be made 2½ times heavier than it was, other proportions remaining the same."

Within the usual sag ratios of 1/9 to 1/12 any variation in cable sag has no marked effect upon the vertical rigidity. The cable sag has a material effect upon the lateral rigidity, the lateral deflection being roughly proportional to the cable sag.

Stiffening girders or trusses are the most effective and most economical means to provide rigidity as far as it is now provided by weight. The effect of the slender type of towers on the static deformation is negligible. Long side spans have a material influence upon the flexibility of the center span.

Without further aerodynamic experiments and experience on actual structures, it is not possible to set a limit to torsional flexibility. On the Tacoma Narrows Bridge, an increase in width to 53 ft., an increase in weight by 100 percent and stiffening trusses 24 ft. deep would be required for a torsional rigidity approaching that of the Golden Gate Bridge.

Wind forces are classified as static, or steady, and dynamic, the former being the force usually considered in structural design and expressed in pounds per square foot, this force varying as the square of the wind velocity. The wind tunnel tests indicate that the 30 pounds on 1½ times the exposed surface assumed for the design of the Tacoma Narrows Bridge was equivalent to the pressure produced by a wind velocity of 108 mph.

Aerodynamic forces

Three possible sources of dynamic action were considered; aerodynamic instability (negative damping) producing self-induced vibrations in the structure; eddy formations which might be periodic in their character; and the random effects of turbulence, in fluctuations in the velocity and direction of the wind. These sources require separate consideration in seeking the causes of the vertical and of the torsional oscillations.

Vertical oscillations

The first wind tunnel tests on a model of a section of the Tacoma Narrows Bridge at the University of Washington, as reported in *Engineering News-Record*, indicated that the bridge was aerodynamically unstable —i.e., in a steady wind stream self-induced vibrations would be established. A check of these results at California Institute of Technology on a model with a larger aspect ratio (representing a longer length of the bridge so as to eliminate the end effects in the wind tunnel) failed to substantiate these results but showed instability when the depth of the girders was increased. Even with these deeper girders the negative air damp-

ELASTIC PROPERTIES AND COMPARATIVE DEFLECTIONS OF FIVE LONG SUSPENSION BRIDGES.

Name of Bridge	Tacoma Narrows	Golden Gate	Bronx-Whitestone	S. F. Bay	George Washington
GENERAL DIMENSIONS AND WEIGHT					
Length of center span, feet	2,800	4,200	2,300	2,310	3,500
Length of side spans, feet	1,100	1,125	735	1,160	650
Width between cables, feet	39	90	74	66	106
Average weight of center span, lb. per lineal foot	5,700	21,035	11,000	18,740	31,590*
PROPERTIES OF CABLES					
Number of cables	2	2	2	2	4
Cable sag, feet	232	475	200	231	319.2*
Diameter, inches	17½	36⅜	22	28¾	36
Net section, all cables, sq. in.	383	1,664	594	1,050	3,195
PROPERTIES OF STIFFENING GIRDERS					
Number of girders and type	2 pl. girders	2 trusses	2 pl. girders	2 trusses	2 chords
Depth (c.c. chords for trusses), feet	8	25	11	30	.....
Mom. of inertia, all girders, in.² ft.²	2,567	88,000	5,860	156,000	168
PROPERTIES OF LATERAL SYSTEM					
Horiz. wind force acting on floor and vehicles, lb. per lin. foot	560	1,130	800	1,400	1,200
Horiz. wind force acting on cables, lb. per. lineal foot	60	200	120	145	300
Total wind force on floor and cables, lb. per lineal foot	620	1,330	920	1,545	1,500
Width of wind truss, feet	39	90	74	66	106
Mom. of inertia, wind truss, in.² ft.²	95,000	1,236,000	410,000	743,000	481,000*
PROPERTIES OF TOWERS					
Height of towers (top of pier to center of cable)	425	702	353	462.41	582
Width at top (parallel to bridge axis), feet	13	24.6	12	15	37.5
Width at bottom (parallel to bridge axis), feet	19	52.6	18	32	56
Area at top — both tower legs	1,524	7,340	3,300	3,712	5,978
Area at bottom — both tower legs	2,287	14,384	4,200	8,000	14,624
Aver. M. of I, both tower legs, in.² ft.²	40,500	1,500,000	60,000	290,000	3,130,000
VERT. DEFLECTIONS FROM LIVE LOAD AT NORMAL TEMPERATURE					
Live load, lb. per lin. ft. bridge	1,500	4,000	3,000	6,000	4,000
Down at ¼ pt. center span with load on ½ center span, tower to center	10.95	12.41	8.41	10.70	5.88
Up at ¾ pt. of center span, same loading	2.74	6.72	3.30	7.50	3.54
Down at center-load center span	10.50	7.34	6.50	11.85	2.92
Up at center-load side spans	5.93	2.34	2.35	8.18	0.48
Maximum change in grade, %	3.6	2.6	2.8	3.3	1.2
Maximum grade, %	6.2	5.7	6.8	6.3	3.4
Tilting from live load at ¼ pt. of center span, %	17.54	10.88	7.88	14.27	4.44
Lateral deflection of truss from design wind at center of center span, ft.	20.03	21.5	8.93	11.42	10.7
Maximum longitudinal deflection of tower top from live load, ft.	1.98	1.36	0.83	2.53	0.34
Relative vertical rigidity at quarter point	1.0	2.3	2.6 (a) / 3.0 (b)	4.0	5.0
Relative torsional rigidity	1.0	4.2	4.4 (a) / 5.9 (b)	4.9	14.1
Influence of stiffening girders on cable deformations, %	1.3	7.5	2.5	29.0	0

(a) Without stays.
(b) With stays.
* Single Deck Condition.
Final Condition — 39,500 lb. per lin. ft. of bridge. Sag 325 ft.

ing disappeared when the amplitudes on the prototype exceeded 18 in. Moreover, wind tunnel tests made on a model of the Golden Gate Bridge at Stanford University did not indicate any aerodynamic instability and therefore this reason does not explain the vertical oscillations which have been observed on that structure. Slight aerodynamic instability may be overcome by a small amount of structural damping.

Variable forces may result from the eddy formation which occurs with the air flow around bodies with sharp edges and of blunt cross-sections. These eddies occur, in many cases, with a periodic rhythm, and when their period coincides with the natural period of the structure a resonant oscillation may develop. To develop periodically alternating lift forces on the structure it would be necessary that eddies be produced alternately at the upper and lower edges of the girders. To decide this question, velocity fluctuation measurements were conducted on a model of the roadway. The fluctuations were measured by a hot wire anemometer which permitted simultaneous recordings at the upper and lower edges of the front girder. The fluctuations were of a large order and fairly periodic but the fluctuations were more frequently in phase than otherwise. Flow pictures, taken by Beeuwkees at the Case School of Applied Science, of a model in a tank showed similar periodic eddies, but when the model does not oscillate in torsion the eddies are not alternating.

The board believes the most satisfactory explanation of the vertical oscillations is that of forced vibrations excited by the random action of turbulent wind. Because of its natural turbulence, the velocity and direction of the wind at a fixed point is subject to random variations. Consequently, the horizontal wind pressure and the lift forces are varying. The vertical forces vary not only in amount but also in direction and are apt to produce vertical oscillations of the roadway. These fluctuations are random, without definite periodicity. Nevertheless, these fluctuations exert an action similar to a great number of superimposed periodic fluctuations. The deflections produced by those fluctuations whose period approaches one of the natural frequencies of the structure will be amplified especially if the structure is not sufficiently damped. Higher frequencies of these fluctuations prevail in winds of higher velocity. This explains the correlation between modes of oscillation and wind velocity (Fig. 1).

Torsional oscillations

The board conducted oscillatory tests in the wind tunnel on a number of suspension bridge models and

SUMMARY OF CONCLUSIONS OF FWA REPORT ON TACOMA BRIDGE

As a result of the investigations which are described in detail in this report, we have reached the following conclusions:

1. The Tacoma Narrows Bridge was well designed and built to resist safely all static forces, including wind, usually considered in the design of similar structures. Its failure resulted from excessive oscillations caused by wind action.

2. The excessive vertical and torsional oscillations were made possible by the extraordinary degree of flexibility of the structure and of its relatively small capacity to absorb dynamic forces. It was not realized that the aerodynamic forces which had proven disastrous in the past to much lighter and shorter flexible suspension bridges would affect a structure of such magnitude as the Tacoma Narrows Bridge, although its flexibility was greatly in excess of any other long span suspension bridge.

3. The vertical oscillations of the Tacoma Narrows Bridge were probably induced by the turbulent character of wind action. Their amplitudes may have been influenced by the aerodynamic characteristics of the suspended structure. There is, however, no convincing evidence that the vertical oscillations were caused by so-called aerodynamic instability. At the higher wind velocities torsional oscillations, when once induced, tend to increase their amplitudes.

4. Vertical oscillations of considerable amplitudes were first observed during the erection of the suspended floor and continued, at intervals, until the day of failure. While, at times, the resulting stresses in the stiffening girders were high, there is no evidence that any structural damage resulted. Under certain observed conditions very high stresses were caused in the ties which connected the suspended floor structure to the cables at mid-span.

5. It appears reasonably certain that the first failure was the slipping of the cable band on the north side of the bridge to which the center ties were connected. This slipping probably initiated the torsional oscillations. These torsional movements caused breaking stresses at various points of the suspended structure and further structural damage followed almost immediately. The dropping of the greater part of the suspended structure of the center span was made possible by the failure of the suspenders. This was followed by the sudden sagging of the side spans with resulting bending and overstressing of the towers and of the side spans.

6. The suspension type is the most suitable and the most economical that could have been selected for the Tacoma Narrows Bridge. No more satisfactory location could have been chosen.

7. Both the Public Works Administration and the Reconstruction Finance Corporation were entirely justified in assuming that, because of the experience and reputation of the consultants employed by the Washington Toll Bridge Authority, there could be no possible question as to the adequacy of the design. Both agencies exercised thorough and competent supervision during the construction of the bridge.

8. There can be no question that the quality of the materials in the structure, and the workmanship, were of a high order.

9. Certain parts of the towers were severely overstressed and permanently deformed during the failure. While there is no visual evidence of damage to the cables, except at the center of the north cable, it is probable that they were overstressed during the torsional oscillations and as a result of the sagging of the side spans. The main piers were not damaged, except locally, during the failure and can withstand considerably heavier tower reactions than they received from the bridge as it existed. The anchorages were not damaged and are safe for forces not greater than those imposed by the original construction.

10. The criteria usually considered for rigidity against static forces do not necessarily apply to dynamic forces.

11. The remedial installations in the bridge represented a rational effort to control the amplitudes of the oscillations. Further installations, including diagonal stay ropes from the top of the towers to the floor were being investigated when the failure occurred, and these would have increased the rigidity. It is doubtful that any measures of this nature would have been sufficient to compensate for the extreme flexibility of the structure.

12. The evidence as to whether the vertical oscillations of the bridge would have been affected by fairing (streamlining) is inconclusive. There is certain evidence that fairing would have had an unfavorable influence on the torsional stability.

13. Further experiments and analytical studies are desirable to investigate the action of aerodynamic forces on suspension bridges.

14. Pending the results of further investigations, there is no doubt that sufficient knowledge and experience exists to permit the safe design of a suspension bridge of any practicable span. The results of further research should furnish knowledge that will permit of more economical design.

15. This report has been restricted to the Tacoma Narrows Bridge, except that available information from other bridges has been considered.

found, for all models, negative air damping, or aerodynamic instability, above a certain wind velocity. For narrow bridges, this limiting velocity is relatively low, 25 m.p.h. in the case of the Tacoma Narrows Bridge. For similar cross-sections, this limiting velocity increases as the ratio of width to the depth of the girder is increased. This negative damping does not become critical, i.e., amplitudes will not become increasingly large, until it is sufficient to overcome the structural damping in the system. The board believes this point to have been reached in the Tacoma Bridge at about 40 mph.

The torsional motions involve distortion of the wind truss (which at Tacoma was 35 times as rigid as the suspended structure in a vertical direction) and also of the concrete floor. The towers are more resistant to torsional than to parallel motions. Consequently, greater structural damping is involved, and this explains why torsional oscillations did not occur at lower velocities and why they were not caused by the random wind effects. Once started these self-induced torsional oscillations become very violent; the amount of energy input in the prototype, estimated as the result of negative damping in Tacoma Narrows Bridge model experiments, gives a figure, for a plus or minus 45 deg. amplitude, on the order of 5,000 hp.

Resistances

The resistance of a suspension bridge to vibrations from dynamic forces is furnished by its rigidity, inertia and structural damping. The Tacoma Narrows Bridge was deficient in all three respects and therefore the amplitudes were greater than have occurred on other bridges. Suspension bridges differ from others in that the potential energy in vibration is largely stored in the form of work done against gravity, that is, the bridge behaves somewhat as a pendulum. The result is that the damping in a suspension bridge is materially less than in other types of bridges. Tests by Farquarhson indicated that the damping constant of a model of the Tacoma Bridge was only 1/30 of that of the more common bridge types. These tests showed the beneficial effects of more rigid stiffening trusses and of friction in the system. The report suggests further investigations of means to secure more structural damping, including participation of the concrete floors in the chord stresses of the stiffening truss and deliberate means of introducing friction, and states "It is at least doubtful that streamlining is the desirable solution for elimination of large oscillations or aerodynamic instability." Nevertheless, it is highly desirable to determine the influence of form on the aerodynamic characteristics of various structures.

It is also pointed out that the criteria for dynamic stability differ materially from those usually considered for static rigidity. Since, for example, the center spans may oscillate without involving motions of the side spans, it is evident that short side spans and even straight backstays have little influence in this respect.

It will never be possible to establish cut-and-dried rules or formulas for the design of long suspension spans; each will require analytical study by the experienced designer. With the emphasis that the Tacoma Narrows Bridge collapse has put on the importance of providing damping, vertical rigidity and torsional resistance, (as distinct from the less important resistance to horizontal deflection under assumed, steady wind forces), there need be no fear that these factors will be overlooked in future competent designs. Long, light suspension spans can now be made safe and adequate.

Fire Extinguisher Maintenance

RAPIDLY EXPANDING building construction and the amount of inflammable material always around construction jobs make it imperative that fire extinguishers are available and ready for instant use. Safety Research Institute makes suggestions:

Fire extinguishers, to be instantly available for use at all times, must be properly recharged and inspected. The date of recharging should be noted on the tag provided for that purpose, along with the name or initials of the man doing the work.

Fire insurance underwriters recommend that only recharging materials and replacement parts furnished by the manufacturers of the extinguishers be used in service work. Full instructions for recharging the various types of extinguishers are given on the labels and they should be followed to the letter.

When the 2½-gallon units are recharged, all parts should be washed thoroughly in water and the water drained through the hose. The shell should be examined to make certain it is sound at the seams, for, after all, it is a pressure container. The head gasket and hose should be examined for signs of deterioration, and the strainer should be cleaned.

All chemical solutions should be mixed in clean containers and not in the shell of the extinguisher, and the container should be carefully rinsed before being used for a new solution.

Do not expose usual type extinguishers to temperatures below a minus 40 deg. F. and do not use anti-freeze crystals.

INSPECTING AND RECHARGING EXTINGUISHERS

Soda-acid: Recharge annually.

Vaporizing Liquid: Recharge after use and keep unit filled at all times. Test action of pump by discharging a portion of the liquid into a clean, dry container. The test liquid can be poured back through the filler opening. Guard against overfilling. No lubricants should be used on the piston of this type of extinguisher, nor should any water be placed in it. Use only filler from the manufacturer as commercial carbon tetrachloride may contain water or impurities making their use dangerous.

Loaded stream: Recharge after use; inspect annually to see if container is filled and that hose and gasket are in good condition. Weigh carbon dioxide cylinder and replace it if it has lost one-half ounce.

Carbon dioxide: Recharge after use; inspect annually to note if seal is intact. Weigh the unit to make certain weight is equal to that stamped on it. Loss of 10 percent in weight indicates the need for recharging.

Foam: Recharge annually.

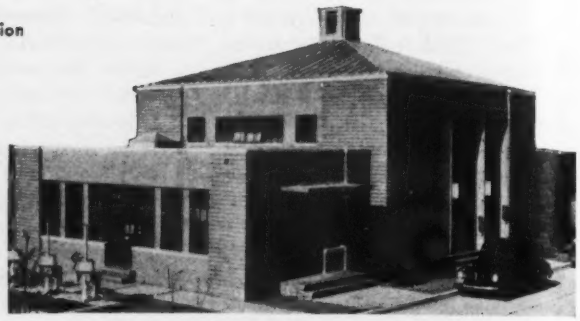
Anti-freeze, pump tank: Recharge after use; inspect annually to make certain it is filled to filling mark. Test pump action by operating pump for several strokes, directing the steam back into the tank.

Anti-freeze, other types: Recharge after use; inspect annually to see if container is filled and that hose, gasket, etc., are in good condition. If carbon dioxide is used for pressure, loss of one-half ounce in the weight of the cylinder is cause for replacing it with a new one.

Sludge Disposal Dominates Plant Design

Harry R. Hall
Chief Engineer, Washington Suburban Sanitary Commission
Hyattsville, Md.

***Contents in Brief**—Sludge processing stands out as the major element of sewage treatment at the new Anacostia River disposal works near Washington, D. C. Employing heated digestion tanks, counter-current elutriation and vacuum filtration facilities, this new plant is also distinguished by extensive use of underground tunnels for access and conduit-carrying purposes.*



Service Building and Laboratory

THERE IS MORE to the Anacostia River sewage treatment works than at first meets the eye. In this new disposal plant for the Washington Suburban Sanitary District a considerable portion of the plant is underground, connected by means of tunnel passageways. The tunnels serve the dual function of carrying pipes and conduits as well as to provide direct access underground to important operating units located in substructures.

This 7½-mgd. plant, which was placed in operation in November to serve a rapidly-growing area in Maryland, adjacent to Washington, D. C., is located on the Anacostia River below Bladensburg, Md. Designed with a view toward eventual installation of complete treatment using activated sludge, the plant at present provides only for the removal of solids by sedimentation. However, the settled effluent is chlorinated prior to discharge. Important auxiliaries to the sedimentation process include: automatic screens and screening grinders, grit collectors and washers, and aerochlorination facilities for the flotation of grease.

Sludge processing facilities

Clearly demonstrating that sludge processing is a major element in sewage treatment at the Anacostia Works, are the elaborate facilities provided for this purpose. These facilities—heated digestion tanks with floating covers for gas collection, elutriation and chemical conditioning devices, and vacuum filtration equipment—are the dominating feature of this modern sewage plant.

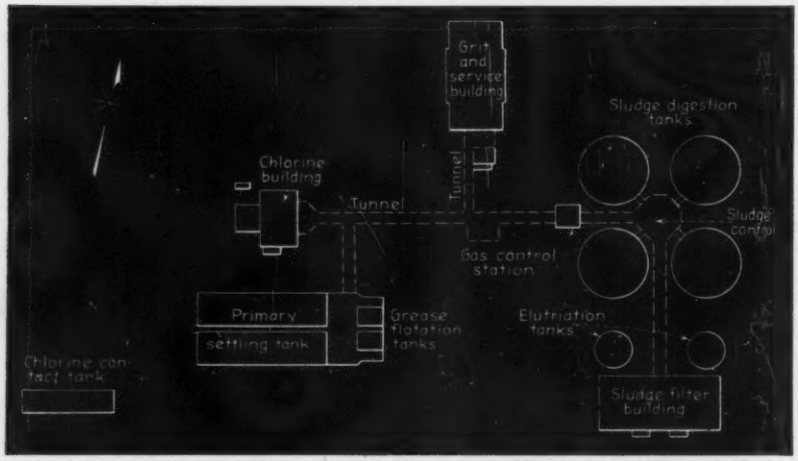
Digestion tanks are standard design, the four 50-ft.-dia. units being grouped around the central control station. Because of gas explosion possibilities, special care has been taken to reduce this hazard by keeping gas pipes out of the principal structures insofar as is possible. Furthermore, all gas metering equipment is grouped within a small building isolated from the other sludge processing structures and constructed with 14-in. concrete walls adequately reinforced.

Elutriation of sludge

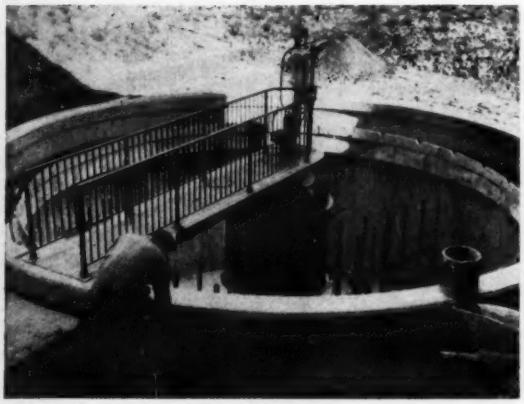
For elutriation (washing digested sludge with water to remove decomposition products prior to vacuum filtration), two 26-ft.-dia. settling tanks and two small rectangular, baffled mixing tanks are provided. The piping for these tanks is arranged for use of the counter-current method of elutriation.

This operation is described as follows by Whitman, Requardt & Smith, consulting engineers of Baltimore, who designed the Anacostia plant:

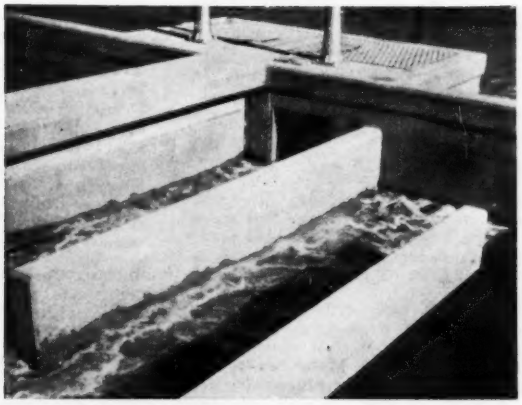
"Digested sludge with or without supernatant liquid from the digestion tank will be mixed with elutriate in the first mixing tank. The mixture will then flow to the first elutriation tank where the sludge will be settled, and the supernatant will overflow to the raw sewage pipe leading to the grease tank. The elutriate for the first mixing tank will be the overflow from



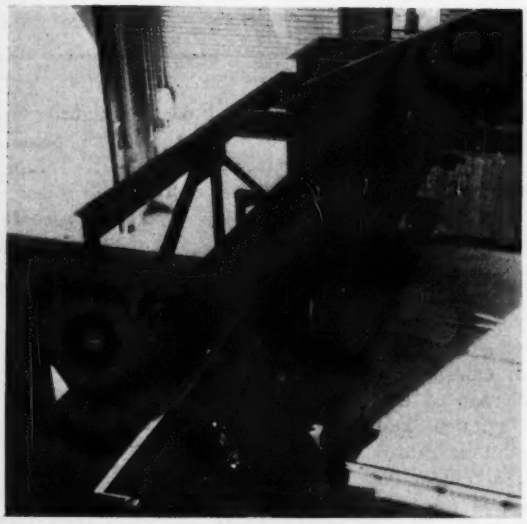
General layout of plant facilities, the major units of which are connected by access tunnels. Provisions have been made for eventual complete treatment.



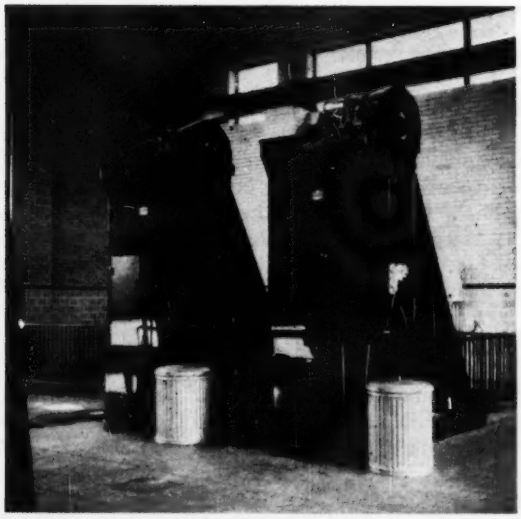
Elutriation Tank



Grease Flotation



Sludge Cake Conveyor



Screenings Grinders

the second elutriation tank. Partially elutriated sludge from the first elutriation tank will be pumped to the second mixing tank where it will be mixed with two or three times as much washwater (either final effluent or groundwater). The mixture from the second mixing tank will flow to the second elutriation tank. The overflow from this elutriation tank will return to the first mixing tank, while the completely washed sludge will be drawn to the storage well in the vacuum filter building, ready for filtering.

"Based upon operating eight hours daily and five days per week, each elutriation tank will provide a surface area of about 120 sq.ft. per ton of dry digested solids. When elutriating, the design flows of digested sludge, plus supernatant liquid, with three-to-one washwater, the detention period in each elutriation tank will be about 1.7 hours. If the supernatant liquid is not elutriated, the detention period with three-to-one washwater then will be about five hours.

"Two variable-speed plunger-type pumps are provided in the sludge filter building for the pumping of partially elutriated sludge from the first to the second elutriation tank. Each pump has a capacity of 14 to 17 gpm., and can be used also for draining the lower part of any digestion tank and for recirculating sludge in any digestion tank or elutriation tank."

Sludge filtration

Vacuum filters are used for dewatering sludge, and the piping is arranged so that material either can be drawn directly from the digesters or from the elutriation tank.

A bucket elevator lifts the sludge from a storage well to a rubber-lined conditioning tank which has a detention period of from 2 to 6 min., de-

DESIGN AND CAPACITY DATA
ANACOSTIA RIVER SEWAGE TREATMENT WORKS

Treatment: Primary treatment with grease flotation and post-chlorination. Units for this purpose are: bar screens, screenings grinders, grit collectors, a grit washer and ejector, air-chlorine grease flotation tanks, primary tanks, chlorine contact tank, chlorinators, blower, floating cover heated sludge digestion tanks, elutriation equipment, and vacuum sludge filters.

Plant Capacity: 7.5 mgd.

Sewage Characteristics: Domestic, no industrial wastes. Average flow about 5.5 mgd. Raw sewage B.O.D.—155 ppm., total suspended solids—130 ppm. Final effluent B.O.D. 70 ppm., total suspended solids—45 ppm.

Screenings: Two mechanically-cleaned bar screens with 1-in. clear openings, capacity 10 mgd. each. Macerated by two grinders of 1,100 lb., or 20 cu. ft., per hr. capacity. Screens are each 3 ft. wide and the normal depth of sewage at this point is 3.5 ft. Ground screenings are returned to sewage.

Grit: Collected from two channels approximately 4.5 ft. wide and 45 ft. long. Velocity of sewage through one grit chamber at 7.5 mgd. rate is about 0.7 ft. per sec. Buckets on continuous chains convey grit to a grit washer of the basket type. Organic matter returned to sewage. Grit used as fill.

Grease Flotation: Two tanks, each 16x20 ft. with two around-the-end baffles to form three channels in each. The channels each have hopper bottoms fitted with 14 diffuser plates 12x12 in. for the introduction of air. Chlorine is added at the influent end of each tank in water solution. Detention period is about 10 min. when using both tanks at 7.5 mgd. rate.

Blower: One unit of 500 cu. ft. free air per minute capacity. At present it is used exclusively for grease flotation.

Primary Tanks: Two flat-bottom tanks each 112 ft. long, 28 ft. wide and with an average sewage depth of 10.5 ft. fitted with sludge and scum collector mechanisms. Detention period at 7.5 mgd. rate of flow when using both tanks is approximately 1.5 hr.

Chlorine Contact Tank: One tank 64 ft. long and 16 ft. wide with normal sewage depth of 7 ft.; provided with seven around-the-end vertical baffle walls. Chlorine is added in water solution. Contact period is about 10 min. at 7.5 mgd. rate.

Chlorinators: Two solution-feed-type chlorinators of 1,200 and 1,300 lb. per 24 hr. capacity. Two rotometers are used to divide the chlorinator output for two points of application—i.e., grease flotation and final chlorination.

Digestion Tanks: Four circular tanks with floating covers each 50 ft. dia. and about 28 ft. deep, heated with hot water coils. Capacity, 43,845 cu. ft. each. Piping is arranged to permit either single-stage or two-stage operation in any tank combination.

Gas Collection: Gas collected from each digestion tank, two waste gas burners, two fuel oil-gas fired boilers.

Elutriation: Two circular elutriation tanks each 26 ft. in dia. and about 11 ft. deep; picket-fence type sludge thickener. Counter-current operation will be used.

Sludge Filters: Two vacuum type units each 250 sq. ft. effective filter area. Dual auxiliaries.

pending on the elevator speed. Here ferric chloride is added, after which the sludge flows to either one or both of two vacuum filters. Each of the latter has a filter area of 250 sq.ft., and is rated at 3 lb. per hr. per square foot of filter surface when a sludge of 94-percent moisture content is applied.

Sludge cake from both filters is collected on a conveyor belt which discharges onto a shuttle conveyor running at right angles to the main belt. The shuttle conveyor is high enough above ground level so that trucks can be loaded directly, and when trucks are not available it is moved back to permit sludge to fall into a storage bin. The latter is cleaned out with a clamshell bucket operating from a traveling crane.

Ultimate disposition of the sludge will be to neighboring farmers and golf courses, or to a nearby district-operated refuse incinerator.

Grease flotation tank

One of the special features of the treatment works is the grease flotation process applied prior to sedimentation. For this purpose a three-pass baffled tank, in which air can be bubbled through the sewage, is employed. Each of the two sedimentation units of the plant is provided with a grease tank.

The tank, 20 x 16.5 ft. in plan, and 11.5 ft. deep, has two longitudinal baffles. These divide the tank into three 5-ft.-wide compartments or channels, on the floor of which are a row of diffuser plates. Sewage entering the tank flows a distance of about 60 ft. before it passes into the sedimentation unit (detention period of 4 to 8 min., depending on flow). Compressed air, which can be fed independently to each row of diffusers, continuously agitates and aerates the sewage, and thus causes grease to be separated and float on the surface. The grease is removed by the surface skimmers in the sedimentation tank.

The quantity of air required for grease flotation will average about 0.1 cu.ft. per gallon of sewage. To increase the efficiency of flotation, provision is made for the introduction of chlorine solution at a point where the sewage enters the tank; the chlorine dosage will vary between 1 and 3 ppm.

Other design and capacity details of the plant and its equipment are given in the accompanying tabulation.

The Anacostia River sewage treatment project was built under the direction of the writer. The engineering design and supervision of construction were executed by Whitman, Requardt & Smith, consulting engineers of Baltimore. The principal contractor was Chas. H. Tompkins Co. The total cost of the project was $796,500; the construction contract was $684,950, and the PWA contribution was $338,000. Herman Kratz is superintendent of the plant.

Public Utilities Owned By Municipalities

Close to 90 percent of the cities over 5,000 population own one or more public utilities according to the International City Managers' Association. The utility owned most frequently by a municipality is the water supply and distribution system. Nearly 72 percent of the cities report they own this utility, according to the Association's 1941 Municipal Year Book. Fifty percent of the cities report ownership of sewage treatment plants; 28 percent, airports; and 20 percent, auditoriums. Electric generating and distributing systems are owned by 13.2 percent of the cities, and 6.9 percent more own an electric distribution system only.

Other utilities owned and operated less frequently by municipal governments are gas manufacturing and distributing systems, port facilities and slaughterhouses.

BUILDING DESIGNERS' LIBRARY

Analyzing Air Conditioning Costs For Blackout Plants

L. Gale Huggins

Engineer, Air Conditioning Department
Westinghouse Electric and Manufacturing Co., East Springfield, Mass.

***Contents in Brief** — Windowless plants place a premium on air conditioning. Four types of air conditioning systems are analyzed for an 840,000-sq.ft. factory of that kind. Lowest cost system that permits year-round operation is indicated to be of independent zone unit type.*

A TYPE OF FACTORY new to American industry is now being built in many parts of the United States. Having solid walls with no windows, a solid roof with no skylights, it is popularly known as a "blackout" plant. An entire absence of daylight openings means that adequate artificial lighting must be provided to facilitate the precision machinework and exact assembly operation required to manufacture the modern airplanes, the ordnance material, and the other highly complicated war supplies that such plants are designed to turn out. And artificial lighting 24 hr. a day means that heat from the lighting units, heat from sun radiation and heat transmission through the building, heat from electric motors, from workmen, and from other sources all occur simultaneously and create air conditions in which workmen cannot carry out their important tasks.

This article describes a careful study made of one of these plants now being built, to determine the best way to remove the heat and provide proper working conditions. This plant consists of several one-story buildings, totalling 840,000 sq.ft., and having a uniform width of 300 ft. In order to study properly and predict accurately the important engineering and economic problems connected with air conditioning a plant of such revolutionary construction, ten different air conditioning systems were designed for this factory by the engineers, and the operation of each type of system was studied from many angles.

Some of the most important considerations for each air conditioning method were:

1. First cost of complete system.
2. Operating cost under expected factory operating conditions and weather conditions.
3. Total horsepower required, including auxiliary power.
4. Flexibility of control under various operating changes.
5. Vulnerability to shutdown due to mechanical difficulties, local sabotage, and damage due to air bombing.
6. Proportion of factory that would be made inoperative, and possible extent of damage due to outage of any one part of the system.
7. Time to reestablish normal operation of air conditioning system after a single section had sustained serious damage.

Forced ventilation not enough

Of the different systems of air conditioning studied, the most inexpensive and simple from the standpoint of first cost was a forced ventilation system. It was found that with ventilation quantities considered practical, the inside air temperature could be reduced to within 6.25 deg. F. of outside temperature. But since summer outside design temperature at the factory location is 100 deg. F., this means a temperature of 106.25 deg. F. in the factory. Obviously such a temperature is prohibitive.

The other extreme in design was represented by a single, large refrigerating plant with an adjacent single, large, central air conditioning plant. Zone supply fans to supply air through ducts to the various buildings were considered. This plan has some operating advantages, as all major equipment is located at a central point so that constant supervision of operation can be provided by a very small number of operating engineers. Some of the disadvantages are: (1) the necessary long duct runs to various buildings are expensive; (2) fans and fan motors required to force air through the long ducts are large and expensive in first cost and in operating cost; (3) mechanical damage to the central refrigerating and air conditioning plant could cause shutdown of the entire factory until repairs could be made. Due to the large equipment involved it would not be practical to provide complete spare equipment, and considerable time might be required to obtain replacement equipment.

Another system studied consisted of a central refrigeration and a water cooling plant supplying cold water to central plant air handling units for each building. Still another system had a similar refrigerating and water cooling plant supplying cold water to smaller zone units located throughout each building.

Both of these air conditioning systems share the hazard of possible damage to the central refrigerating plant, shutting down the entire factory for an indefinite period. The water circulating pumps, motors, and insulated chilled water lines are a large item in first cost. The pump motors increase the power supply required and add to the operating cost.

Other systems studied included a central refrigerating and air handling plant for each building, and a central refrigerating and a water cooling plant for each building with zone units supplied with chilled water by circulating pumps through insulated piping. While these systems showed advantages over those previously discussed, they still made possible the disruption of air conditioning to an entire building due to damage to that building's refrigeration plant. Interconnection of piping between buildings increased the reliability of the entire system, but also increased the first cost and required installation of larger equipment.

Basis for comparison of systems

Table I shows a summary of the study of the four most likely systems considered. Table 2 shows a

further breakdown of operating costs and Table 3 of amortization costs. Complete tabulated data on the other systems studied are omitted, as the data show them to be less favorable than those shown. All studies were based on the following conditions and costs:

1. *Temperature conditions* (from recommendations by the A.S.H.V.E. for the factory location):

For heating:
Outside 0° F. Inside plant 70° F.
For cooling:
Outside 100° F. dry bulb (DB)
78° F wet bulb (WB)
Inside: 84° F. dry bulb
68° F. wet bulb
75° F. effective temperature

2. *Basic power costs:*

Natural gas—$0.14 per M cu.ft.
Electric energy—0.01 per kwh.
Steam—0.165 per M lb.
Water—0.10 per 100 cu.ft.

3. *Floor space* (of manufacturing area of factory): 840,000 sq.ft.

4. *Occupancy:* 1 person per 125 sq.ft. or 6,600 people.

5. *Operating time:* 24 hr. per day, with loads based on factory operation 312 days per year.

6. *Operating schedule* based on climate conditions:

Heating and ventilating, 141 days per yr.
Ventilating only, 63 days per yr.
Cooling and ventilating, 108 days per yr.
Ventilation for a plant without provision for cooling, 171 days per yr.

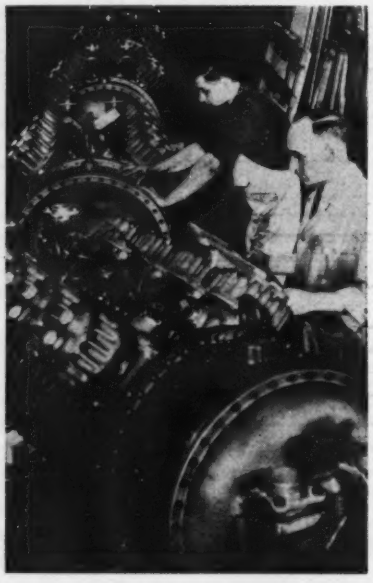
7. *Roof construction:* such as would have insulation to give 0.054 B.t.u. per sq.ft. per hr. per deg. F. temperature difference.

8. *Installation costs:* to cover heating plant equipment, fans, ducts, piping, insulation, compressors, pumps, motors, and wiring. Cost of buildings to house equipment, such as boiler-house, fan rooms, etc., not included.

The four systems considered

System 1 is a conventional forced ventilating system with zone fan units supplying ten complete air changes per hour during summer operation. This quantity, in the factory studied, lowers the inside factory temperature to within 6.25 deg. F. of the outside dry bulb temperature. This allows inside conditions to reach a maximum of 106.25 deg. DB, 78 deg. WB and 88 deg. effective temperature, conditions under which mechanics cannot be expected to perform highly skilled work. Inside temperatures will be above that desired (75 deg. E.T.) for approximately 100 days per year; and for at least 30 days per year the temperature will be so high that normal manufacturing operations cannot be carried on. This system shows the lowest installed cost and lowest operating cost of any of those studied.

System 2 is similar to System 1 in all respects except that spray washers using recirculated water are added to the air supply units to provide evaporative cooling to reduce the dry bulb temperature of the air supplied to the factory. Table 1 shows this effect to be very successful, the dry bulb temperature of the air supplied by the fans being reduced from 100 deg. DB to 83.5 deg. DB and the temperature in the factory being reduced from 106.25 deg. DB to 90.65 deg. DB. However, this is accompanied by an inevitable rise in wet bulb temperature to 80 deg., which gives an effective temperature of 84 deg., only 4 deg. F. below that shown for System 1. Working conditions still cannot be considered satisfactory during summer weather.



Compressors of 100-ton capacity leaving the factory to be installed in independent zone units for air conditioning blackout plants.

System 3 consists of a water cooling plant in a centrally located power plant or machinery room. Cold water mains, suitably protected with ice water thickness insulation, conduct chilled water to and from the zone air conditioning units located throughout the various buildings. A natural draft cooling tower provides condensing water for the refrigeration condenser. Cold water pumps circulate the chilled water through the system.

Each zone contains a fan, cold water cooling coils, heating coils, filters, outside and return air proportioning dampers and a complete automatic control system.

This system provides suitable working conditions, 84 deg. DB, 68 deg. WB, 75 deg. E. T. throughout the summer, and makes continuous summer operation practical. Cost comparisons are given in the tables. This is the highest cost system of the four, but would be somewhat more convenient than System 4 to operate, as the heating, refrigerating, and pumping equipment are centralized. For a defense plant it has one serious disadvantage, a saboteur or well-placed bomb might put the entire system out of operation for a considerable period.

System 4 consists of a large number of relatively small independent zone units. Each unit is completely separate from all others. Each zone unit contains a freon compressor, an evaporative condenser, direct expansion cooling coils, direct gas-fired air heaters, a fan, air filters, return and outside air proportioning dampers, and automatic control. Each zone unit in the factory is identical with all others. Depending on the size and loading of the factory, each unit is usually 50, 75, or 100 tons capacity. For larger plants 100 tons appears to be about the ideal size for each zone unit system. Air conditions in the factory obtained with System 4 are identical with those obtained with System 3 and are considered to be entirely satisfactory from an operating standpoint.

Zone system offers many advantages

Installation of this zone unit type of system is practical in either new or remodeled buildings, as modern light-weight high-speed refrigeration equipment makes it possible to locate the motor-driven freon compressor, the evaporative condenser, the direct expansion evaporators, the fans for circulating conditioned air and evaporative condenser air, all in the roof trusses of the building or on the roof, completely out of the manufacturing space. Air is supplied to a relatively short, small zone duct system. Return air ducts are unnecessary, as return air is drawn directly into the return air connection of the air conditioning units. Proper quan-

tities of outside air are regulated by suitable proportioning dampers at each unit. The evaporative condenser fan also serves as an exhaust air fan for the factory, the amount exhausted being regulated by proportioning dampers.

Study summarized

In summary the study showed that the zone unit system had the following advantages:

1. Lowest first cost due to the elimination of large, insulated duct systems or cold water piping, large fans or circulating pumps, and water chilling units.

2. Lowest in installed horsepower and operating cost due to elimination of large fan or pump motors.

3. Most flexible in operation. Each zone unit operates in response to conditions in its local zone only.

4. Automatically shares the total load. As all the larger buildings had several separate zone unit air conditioning systems, damage to any one of these would result in only a small increase in temperature in that zone, as neighboring zone units would carry at least a part of the load of the damaged zone.

5. Quickly replaced. If a zone unit were damaged, even completely destroyed, it could be replaced quickly, as it would be practical to carry a complete set of parts—a compressor, fan, coils, evaporative condenser, motors, piping, refrigerant, etc.—for a complete zone unit in stock. As all zone units are duplicate, this stock of parts represents only a nominal investment.

Conditions variable

Conditions in other factories being built or planned will vary somewhat due to difference in climate, plant activity, exposure, military importance and other factors. The factory covered by this study is an assembly plant having a rather light motor load and considerable space per man. This results in a refrigeration requirement of one ton per 420 sq.ft. of floorspace. In another factory now being built and devoted to shell machining, the high electric load makes it necessary to install one ton for each 125 sq.ft. of space. It is recommended that each factory be studied to determine the type of air conditioning system which is most directly suited to the particular requirements.

TABLE 1—COMPARISON OF AIR CONDITIONING SYSTEMS

	System 1 Ventilation and Heating	System 2 Ventilation Air Washers and Heating	System 3 Central Refrigeration Zone Air Cond. Units	System 4 Independent Zone Unit Air Conditioning
Volume air handled by fans	1,820,000	1,820,000	1,000,000	1,000,000
Ventilation in hot weather	1,820,000	1,820,000	192,000	192,000
Entire air handled by fan	Ea. 6 min.	Ea. 6 min.	Ea. 11.5 min.	Ea. 11.5 min.
Air in building replaced	Ea. 6 min.	Ea. 6 min.	Every hour	Every hour
Av. air velocity in factory	175 ft./min.	175 ft./min.	100 ft./min.	100 ft./min.
Outside design cond. summer	100-DB 78-WB	100-DB 78-WB	100-DB 78-WB	100-DB 78-WB
Sensible heat gain, B.t.u.-Hr.	12,950,000	12,950,000	16,362,000	16,362,000
DB temp., air leaving fans	100	83.5	69	69
Air temp. rise from heat gain	6.25	6.25	15	15
Conditions in Factory DB	106.25	90.65	84	84
" " " WB	78	80	68	68
" " " ET	88	84	75	75
Hp. to drive vent. fans	720	720	540	540
Hp. washer or cold water pumps	.....	270	300	.....
Hp. refrig. compressors	.....	.....	1950	2000
Hp. pumps for cooling tower or evap. condenser	.....	.....	300	100
Hp. fans for cooling tower or evap. condenser	.....	.....	Natural draft	200
Total installed hp	720	990	3090	2840
Cost, system installed	$462,000	$494,000	$660,000	$590,000
Cost per sq. ft	$0.55	$0.575	$0.786	$0.704
Annual fuel, water, power cost (Details in Table 2)	$41,260	$56,510	$73,660	$64,000
Annual oper. cost per sq. ft.	$0.05	$0.067	$0.088	$0.076
Total oper. cost per day	$132	$181	$236	$205
Oper. cost per man-hour	$0.0011	$0.0015	$0.002	$0.00175
Total ann. cost (See Table 3)	$167,460	195,210	262,460	239,400
Total cost per man-hour	$0.0045	$0.0052	$0.0071	$0.0064

TABLE 2—OPERATING COST ANALYSIS

	Fuel	Water	Power			Total Fuel, Water, Power
			Ventilation Fans	Pumps Washer or Chill Water	Compressors or Auxil.	
System 1						
Heating & ventilating 141 days	$5,860		13,500			
Ventilating only 171 days			21,900			
Total per yr.	5,860		35,400			41,260
System 2						
Heating & ventilating 141 days	5,860		13,500			
Evap. cooling & vent. 108 days		10,000	13,800	5,250		
Ventilating only 63 days			8,100			
Total per yr.	5,860	10,000	35,400	5,250		56,510
System 3						
Heating & ventilating 141 days	5,860		10,300			
Cooling & ventilating 108 days		6,200	9,900	4,330	30,370	
Ventilating only 63 days			6,700			
Total per yr.	5,860	6,200	26,900	4,330	30,370	73,660
System 4						
Heating & Ventilating 141 days	5,860		10,300			
Cooling & Ventilating 108 days		5,200	9,900		26,040	
Ventilating only 63 days			6,700			
Total per yr.	5,860	5,200	26,900	.....	26,040	64,000

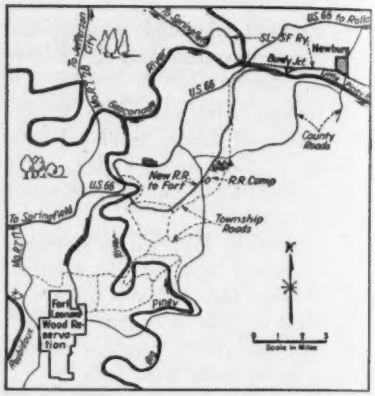
TABLE 3—AMORTIZATION AND MAINTENANCE COST

Yearly Write off	$92,400	$99,000	$132,000	$117,700
Average interest	13,800	14,700	19,800	17,700
Yearly operating exp	41,260	56,510	73,660	64,000
Yearly maint. and wages	20,000	25,000	37,000	40,000
	$167,460	$195,210	$262,460	$239,400
Cost per sq. ft. per yr	$0.195	$0.232	$0.313	$0.285
Cost per day (312 days)	$536	$622	$842	$768
Cost per man-hour	$0.0045	$0.0052	$0.0071	$0.0064

Note: Plant write-off 20 percent of first cost per year. Interest is average over 5-year period at 5 per cent. Maintenance and wage cost estimated.

Building a Camp in the Wilderness

***Contents in Brief**—Biggest handicap in building Fort Leonard Wood, one of the largest army camps in the country, is its isolated location in the Ozark Mountains, 35 miles southwest of Rolla, Mo. Nearest railroad is 25 miles, and nearest hard-surfaced highway is 5 miles from the camp. Nearly 70 million board feet of lumber for 1,690 buildings and all other materials, supplies and equipment, had to be trucked to the site. Unusually wet weather added to difficulties. Construction is on time and camp will be completed May 25.*



Map of Fort Leonard Wood location and layout of the camp. U. S. Route 66 is the only paved road between the railhead at Newburg and the job. Much hauling is done over back country roads.

No Army Camp in the country has been more maligned and criticized than has Fort Leonard Wood, under construction in the Ozark Mountains 35 miles southwest of Rolla, Mo. Yet, in light of unprecedented conditions and difficulties, no camp deserves more praise for the swift and efficient manner in which construction is being carried out. This camp was originally scheduled for Leon, Iowa, estimated to cost $8,411,000. Alvord Burdick & Howson, Chicago, were named architect-engineers, and the cost-plus-fixed-fee construction contract was awarded to a combination of four Iowa contractors—C. F. Lytle Co., Western Contracting Corp., W. A. Klinger, Inc., all of Sioux City, and Arthur H. Neumann & Bros. Inc., Des Moines.

Surveying was under way and equipment and materials were rolling into the Leon site when it was discovered no adequate water supply was available in that area. Suddenly on Nov. 4 the camp was moved to a location in Mark Twain National Forest in the heart of the Ozark Mountains, 25 miles from the Frisco Ry. at Newburg, Mo., and 5 miles from U. S. Route 66, the nearest hard road. Not only was the camp moved but it was enlarged to become the main training and replacement center for the 7th Corps Area, which has its headquarters at Omaha, Neb. The extent of the enlargement can be appreciated by the latest estimate of cost of construction, $30,000,000, which will provide accommodations for 40,000 soldiers. Naturally, under such violent disruption of original plans there were bound to be delays, with corresponding hardships to those concerned, but the way difficulties have been overcome is a credit to all.

The work order to proceed with the relocated camp was received Nov. 28. Bad weather had set in, plans had to be revised, and although work was pushed from that date, construction did not get into full swing until late in January. Meantime the army and the contractors reorganized to handle the increased program. An experienced constructing quartermaster was placed in charge, and the contractor secured a new project manager from outside their own organizations.

Tractors dragged lumber trucks through mud fields before roads were built in the camp area.

Construction Variety

Unloading a trainload of lumber (upper left) which was one item to be hauled 25 miles to the job. Grading the camp site (upper right). Railroad grading (lower left) involved 1,235,000 cu. yd., including 265,000 cu. yd. of rock. Some of the bridges (lower right) were reassembled veteran structures with previous railroad service.

By mid-February the payroll was running more than $900,000 per week. During March the payroll climbed to well over $1,000,000 weekly; some 31,000 workmen were on the rolls and daily employment registered a maximum of almost 30,000. By this time the building progress reached the pace of a building placed under roof every 21 min., and nearly 900,000 b.ft. of lumber was nailed up every day. The project was 66 percent complete on March 29.

Job conditions

The war department staked out a reservation of 65,000 acres in the national forest, of which some 6,500 acres comprises the camp area. It is located high in the rolling divide between the Gasconade and Big Piney rivers. Newburg, a division point on the main line of the Frisco, 25 miles to the northeast, is the nearest rail head and the shipping point for all materials, equipment and supplies except those that come from their original source by truck. About 85 percent of all materials and supplies come by rail and must be unloaded at Newburg for truck haul to the job. The material clerk's report for March 12, when the job reached 44 percent completion, shower 4,131 carloads of materials had been received to date in the Newburg yards. Shipments were then at the rate of 80 cars per day; 2,000 cars were unloaded in February.

Transportation of materials to the job was the biggest problem. A railroad to the camp is required for camp operation, and first intentions were to rush the 25-mile spur from Newburg in time for construction use. However, location difficulties through the rough terrain and troubles in obtaining right-of-way delayed the railroad construction to the point where it is now being rushed to meet the camp completion date of May 25. Therefore, all hauling had to be done by trucks. One item alone, 70 million b.ft. of lumber, indicates the magnitude of this haulage problem.

U. S. Route 66, a two-lane concrete road, runs southwest from Newburg, passing the reservation 5 miles to the north. A graveled road, state route 17, leads from the west side of the camp to Route 66. The only other highway access from Newburg to the job was over two or three country routes, all in poor condition. Regardless of route it is 25 miles by road from Newburg to the job. The contractors used all available roads, building low-water stream crossings around inadequate county bridges. The stretch on state route 17 between camp and the hard road was improved and is being maintained by the contractor.

Upon reaching the camp site, transportation around the job was still a problem, as local and temporary roads were churned into ribbons of mud. In the early days the contractors were compelled to sidetrack camp street construction and concentrate on buildings and utilities. Finally, however, heavy hauling was stopped for three weeks in January while a

system of camp roads and streets of crushed rock was built. Some of the heavy-traveled roads have been maintained by treatment with calcium chloride, and later some will probably be surfaced.

The state has plans for widening Route 66 to four lanes from St. Louis to Springfield, building a grade separation at the junction of 66 and 17, and relocating Route 17 around the reservation. This work, however, awaits federal financing, as the state has no money available, though plans are being considered for building the grade separation and 4 miles of access road to the camp as a WPA project.

Power for the job had to await the construction of 26 miles of high-tension lines completed Feb. 10, so scores of temporary light plants were obtained for light and power in the early days, many of which are still in use in isolated areas.

Living quarters for the vast construction army are at a premium in this sparsely-settled Ozark region. Most of the office and supervisory personnel live in Rolla, 10 miles east of Newburg. Some of the thousands of workmen live in the surrounding small towns, even as far away as Jefferson City, 75 miles, but most of them live in tent and trailer communities that spring up around every big construction job, creating a serious problem in health and camp sanitation.

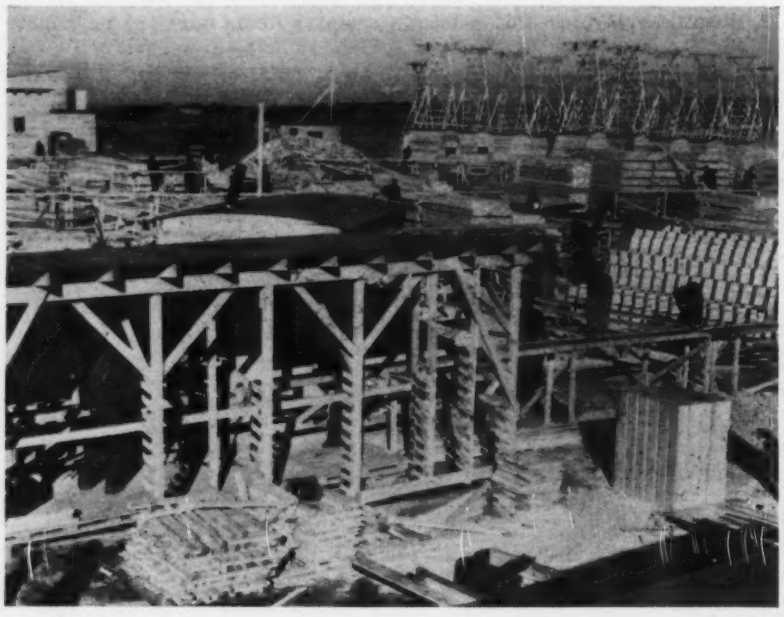
The 1,514 camp buildings are arranged in 19 groups around all four sides of a rolling rectangular parade ground 3,000 ft. wide and 7,000 ft. long. Building design is typical of all camps, construction is wood siding over gypsum wallboard with sheetrock or fiberboard interior. Within the camp are 47.5 miles of streets, all crushed rock construction. About 20 miles probably will be surfaced with concrete or bituminous material, but this work has not yet been authorized.

The water system includes 51.3 miles of pipe, a 4-mgd. filter plant, a 1½-mg. concrete reservoir and a 500,000-gal. steel elevated tank. Supply is from the Big Piney River, 3 miles away, where a pumping plant is being installed. Another pumping plant is located at the filtration plant. A 3-mgd. sewage treatment plant of the trickling filter type is being built about a mile north of the camp. Sewer lines total 36.9 miles.

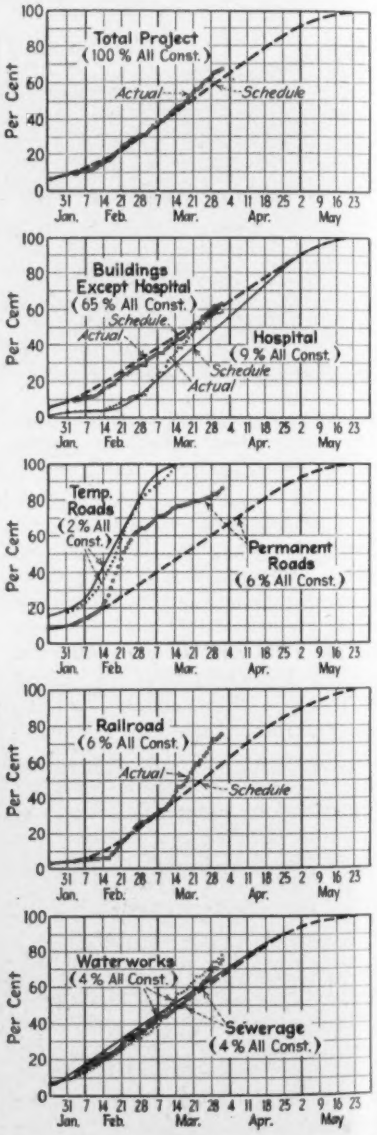
Railroad line

The railroad is the outstanding feature of this particular camp. Including passing tracks and sidings, it involves 30.5 miles of line. First estimates placed the amount of grading at 350,000 cu.yd., latest estimates are 1,235,000 cu.yd., including 265,000 cu.yd. of rock. The line connects with the Frisco at Bundy Junction, in the Little Piney River valley, 2 miles west of Newburg. Numerous small streams and deep ravines require 15 timber trestles in addition to the main river crossings. Maximum grade is 2.25 percent.

Much of the material for the railroad came from the 20 miles of line recently abandoned by the Santa Fe when the government relocated that road around the proposed John Martin reservoir at Caddoa, Colo. The entire line was shipped to Missouri—rails, ties, fittings, bridge timbers and signal equipment. Two old 152-ft. through truss spans for the Big Piney



Heart of the camp construction is the central sawmill, containing nine lanes of power saws for mass cutting of building members. Note the portable light towers in the background.



Progress charts indicate that actual construction was ahead of schedule on the project as a whole and on the various elements.

TABLE I—FIELD LABOR CLASSIFICATION

(March 28, 1941)

Operation	Supervisory	Clerical	Skilled	Semi-skilled and truck drivers	Common	Total	Percent
Railroad	183	74	1,011	...	513	1,781	7.1
Buildings	662	219	10,514	...	6,115	17,510	69.3
Roads, streets	64	8	256	16	348	692	2.6
Conc. Mat'ls.	30	23	208	229	142	632	2.5
Pipeline	140	26	885	82	1,766	2,899	11.5
Electrical	32	9	322	29	143	535	2.1
Safety & San.	22	9	48	...	177	256	1.1
Traffic, Maint.	11	4	52	3	34	104	0.4
Mech. Subs.	44	19	586	43	168	860	3.4
Total	1,188	391	13,882	402	9,406	25,269	100.0
Percent	4.7	1.5	54.9	1.6	37.3	100.0	

crossing and one old 162-ft. span for the Little Piney bridge were obtained from the Frisco Ry. In addition some 950,000 b.ft. of trestle timber had to be purchased new, as well as more than 2,000 timber piles from 20 to 70 ft. long.

Camp construction

Two sand and gravel pits, one on the Big Piney and one on the Roubidoux—both near the job—and three nearby quarries were opened up for the production of road material, concrete aggregates and filter stone. Pit-run material was used for a few of the roads, but all other material is crushed and screened, and the sand and gravel for concrete is washed.

An innovation on this job in building foundation excavation is the use of trenching machines that cut trenches in which the heating plant walls and foundation pedestals are placed. The contractors tried digging individual pedestal pits by hand, but claim the trenching and corresponding backfilling with bulldozers is faster and cheaper.

All framed lumber is cut to dimensions, including notching, at a central sawmill yard. There are nine saw lines, with three to four power saws and routers in each lane. Short pieces for a building unit are bundled together by steel straps for easy handling.

Concrete for building foundations and the sewage and water plants is supplied by four central plant outfits, which can be easily moved, each consisting of a batcher charged by a clamshell crane and a paving mixer. Mixed concrete is hauled to the forms in flat-type hopper buckets by trucks. The buckets are handled from truck to form by cranes.

Railroad construction

Because of the delay in getting started on the railroad, this part of the work had to be organized for unusually high-speed production. Nineteen complete grading outfits belonging to outside contractors were hired, includiing shovels, trucks and tractor-haulage units, bulldozers, graders and rollers, with operators for each rig. One skid piledriving rig was built on the job, and cranes are converted to piledrivers when required. The various outfits, complete in themselves, were assigned to definite portions of the line, starting at the railroad junction end. As each outfit completes its assigned stretch of line, it is bypassed around the other outfits to a new section.

Bridge, trestle and culvert crews work independently of the grading outfits. Material and equipment are dragged, hauled or pushed to the desired location over country roads or over trails cut out by bulldozers.

Excavation is heavy, and the cuts and fills run up to 75 ft. Fills are deposited in layers, tamped with sheepsfoot rollers. Cuts are trimmed to smooth slopes by the shovels as they work down, while embankments are given a final finishing by hand for good appearance.

TABLE II—ARCHITECT-ENGINEER ORGANIZATION

Alvord, Burdick & Howson

Supervising engineer: D. H. Maxwell
Office engineer: H. Allen
Chief architect: V. A. Matteson
Department chief engineers—
Railroad: R. F. Bundy
Sewers: R. E. Crawford
Location: Wm. A. Heins
Roads, streets: Carl P. Lechner
Layout: Francis A. Robinson
Waterworks: F. G. Gordon

Job organization

A breakdown of the labor classifications on a typical day when 28,117 persons were working is shown in Table I.

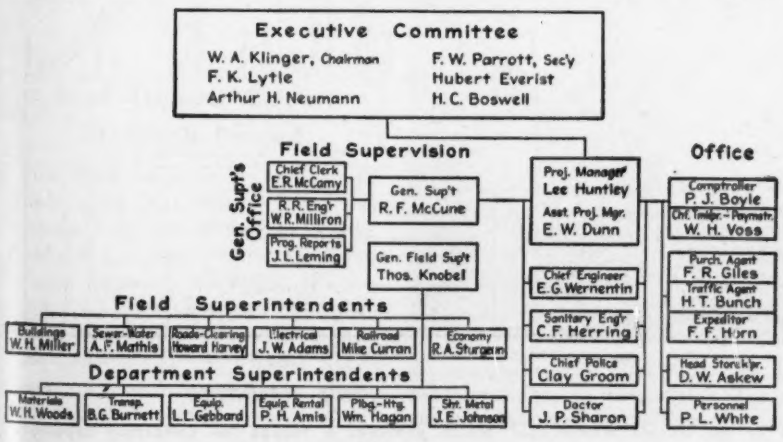
There is a tremendous amount of equipment in use on the job. Lack of space prevents publishing a full list, but following is a summary taken from the daily report of Feb. 21: railroad, 188 units (since greatly increased) including shovels, trucks, cranes, draglines, rollers, tractors; building, 289 units, mostly trucks; roads, 461 machines, mostly tractors and scrapers, trucks and graders; concrete, 335 units, mostly trucks; sewer and water, 141 machines; electrical, 36 units; and traffic and maintenance, 18 trucks and graders.

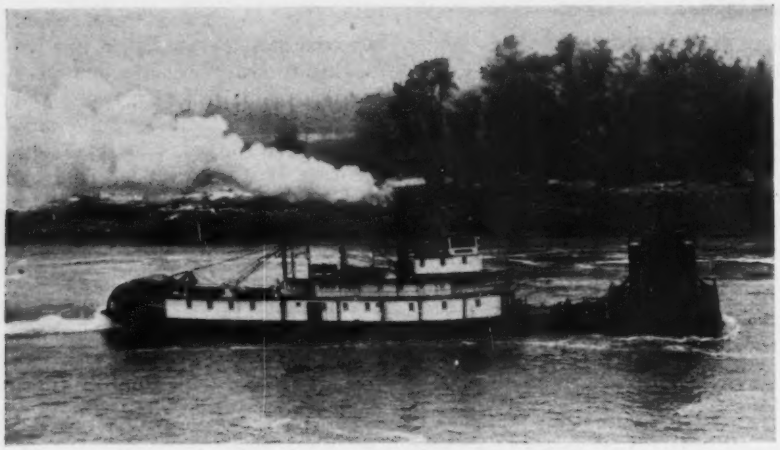
The architect-engineer organization is shown in Table II.

The contractors' organization set-up and personnel are given in the accompanying chart. An executive committee sets the job policy and procedure, but actual direction of the work is under the project manager.

Major Frank Reed, Jr., Quartermaster Corps, is constructing quartermaster in charge for the army. Major M. E. Townes is the zone constructing quartermaster with headquarters at Omaha, Neb.

Organization is the key to every big construction operation. The contractors developed this efficient organization and found capable men to fill all spots.





On its way up the Columbia River to Bonneville Dam the caisson was equipped with a false timber bottom which reduced its draft to 5 ft.

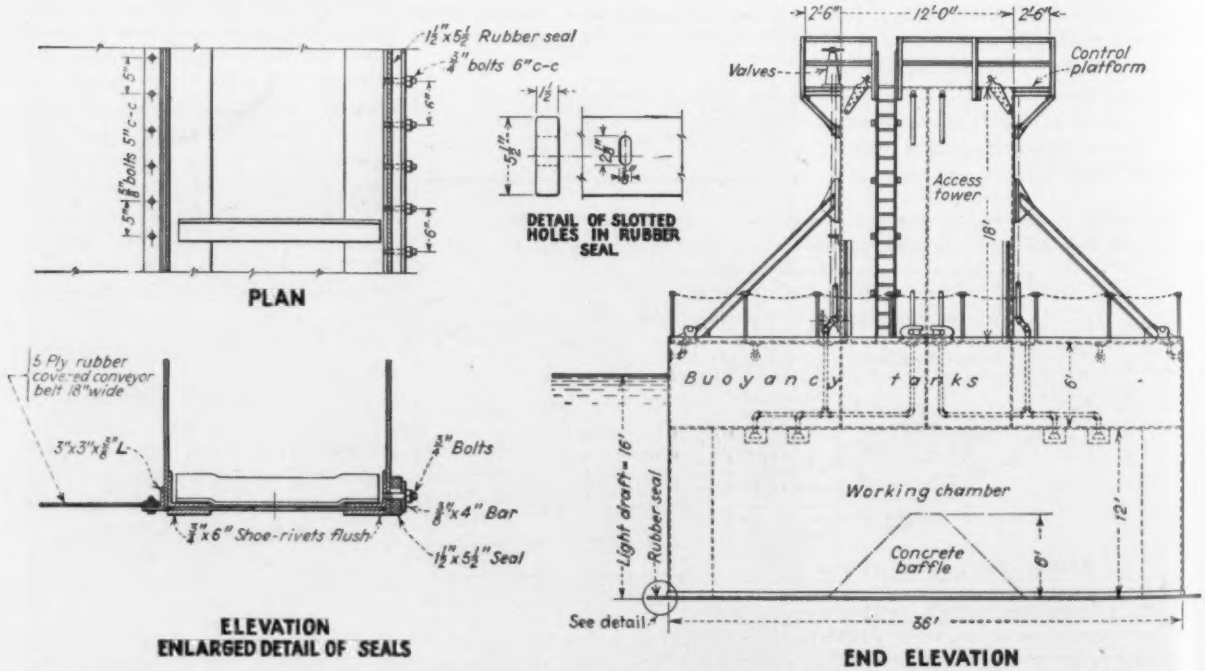
Caisson of Novel Design Used for Repairing Submerged Concrete

A STEEL CAISSON for use in making repairs to baffle piers on the downstream apron of Bonneville Dam recently was built and launched at Portland and towed up the Columbia River to the dam. In principle, the device is an open caisson so designed that when unwatered, the downward pressure of water (totaling some 300 tons) on the deck of the submerged lower chamber is utilized in holding the caisson in position in turbulent water while repairs are made by men working inside. The caisson is made of structural steel, sheathed with steel plates and weighs 200 tons. It draws 16½ ft. of water when floating ready for service but for the trip up the river (see illustration) to the dam a false timber bottom was used, which reduced draught to approximately 5 ft.

The caisson includes a lower or working chamber, an access tower, buoyancy tanks, compressed air receivers for unwatering the buoyancy tanks, gate valves for flooding and rubber seals. The lower chamber is rectangular, 38x36 ft. in plan and 18 ft. high. The access tower is 23x12 ft. in plan and 18 ft. high, making a total height of 36 ft. Buoyancy of the caisson is varied by two watertight compartments in opposite ends of the access chamber and six tanks in the upper portion of the lower chamber, reached by compressed air lines for blowing out the water and valves for controlling water inflow.

Valves for controlling air flow as well as those that admit water to the lower chamber and the buoyancy tanks are controlled from the operating platform on top of the access tower. From this control point buoyancy may be adjusted so as to raise or lower the caisson.

Special interest centers in the seals of novel design which effect watertight joints along the bottom edges; that is, between the bottom of the caisson and the concrete apron of the dam. Essentials of these seals are two rubber strips. One is a ⅛x18-in. run of rubber belting which projects horizontally around the entire outer periphery of the caisson bottom. The other is a 1½x5½-in. strip of tread-



End elevation of the caisson with details of the double water seal, which provides a trough for collecting seepage.

stock rubber fixed vertically on the inside of the open chamber so that its edge rests on the concrete. This second strip is attached to the bottom of a steel plate 2 ft. high fastened to the inner flanges of the bottom girders. This plate and its seal completes a sump or trough in which seepage that comes past the outer seal is retained until removed by pumping, thus keeping the inner portion of the chamber free from seepage.

Caisson operation

In operation the caisson is tended by a 35-ton derrick barge and an equipment barge carrying air compressors and a 14-in. unwatering pump. To insure safety in operating the caisson, buoyancy is adjusted until the effective weight is less than 13 tons after which the derrick performs the actual raising and lowering. The design contemplates that unwatering will require one hour plus such time as may be necessary to remove seepage. A diver is used to direct the final lowering to make sure the caisson goes down into place covering three of the baffle piers which are 6x14 ft. in plan, spaced on 12-ft. centers. Adjustments in position along the dam axis are made by holding-cables to both river banks and to a gantry crane on the deck of the dam.

When lowered to final position, the buoyancy tanks are flooded and the lower chamber unwatered. Thus the 10-ft. water depth on the lower chamber deck aids in holding the caisson in place. After repairs are completed and before raising the caisson, the lower chamber is again flooded and buoyancy tanks are blown down until the weight is about 13 tons.

The caisson was built under contract for the U. S. Engineer Department, North Pacific Division.

Port Orford Cedar Strength Raised

The basic value for the modulus of elasticity of Port Orford Cedar has recently been raised by the Forest Products Laboratory from 1,200,000 lb. per sq.in. to 1,500,000 lb. per sq.in. This revision represents a correction which should be made on page 105, Table 20, in the "Wood Handbook," a publication of the Forest Products Laboratory.

Old Steel Makes New Building

Jos. C. Coyle
Yuma, Arizona

***Contents in Brief**—Ingenuity and salvaged material combined to make Yuma, Arizona's largest fireproof commercial building. Old trusses were reused without dismantling, handled by improvised rigs.*

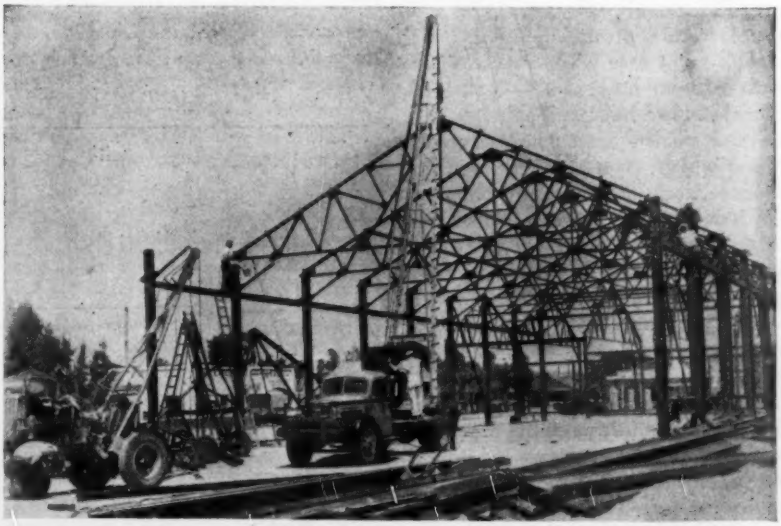
SALVAGED STRUCTURAL STEEL from a 50x200-ft. building at a worked-out mine in northern Arizona was shipped to Yuma and, supplemented by about 20 tons of used steel from other sources, formed the principal material required to build Yuma's latest and largest fireproof commercial building, completed last fall by the Ben Hulse Tractor & Equipment Co. The new building is the same width as the old, but is 215 ft. long, with a 25x 50-ft. ell on the front, where 75 ft. of the old framework was turned at right angles to the remainder and removed 15 ft. from it. The additional space was needed and permits a good connection at the roof junction.

Equipment used for construction was that which was at hand or which could be made by ingenious use of pieces available.

Columns set first

Accumulated grease and dirt was removed from the steel with a steam cleaner to facilitate later painting, and the wall columns were cut off to proper length with an oxyacetylene torch. Reversing the usual procedure in building construction, the next operation was to erect the columns in final position and block them securely, then place the concrete footings, 3 ft. deep and 3 ft. square at the bottom, tapered to 2 ft. at the top. The 4-in. reinforced-concrete floor slab was then placed, in alternate squares 15x24 ft., over the entire building floor area. Fiberboard strips were used as 1-in. expansion joints between squares and around the column footings being later removed and the space filled with compound. The large expanse of floor has retained a perfect surface despite an earthquake, which did considerable damage in the area, and intense summer heat.

Steel was moved in from the rear lot with what was once a track-type tractor with tracks replaced by pneumatic tires at the rear and a small dual castor wheel in front. This was equipped with a 15-ft.-long boom of welded pipe at the rear and counterbalanced in front with sandbags. This rig carried the 50-ft. trusses into the building area one at a time setting them up against the columns. The



A salvaged tractor, left, with rubber tires replacing original track treads, handled the trusses to point of placement. The derrick, rigged on the back of the truck, set them in position.

trusses were then raised to place with a 40-ft. steel boom, hinged to an 8x8-in. angle bolted across the rear of a 5-ton truck, power for handling being supplied by a gasoline-driven two-drum hoist, which was mounted behind the cab on a special frame. Two lengths of heavy steel shafting were carried in a welded frame on the front of the truck as a counterweight. The previously prepared concrete floor facilitated movement of the handling equipment.

Walls of the 50x75-ft. showroom and one wall of the 45x50-ft. stockroom are double. They are stuccoed on metal lath which is tack-welded in a few places but is generally wired to ½-in. round reinforcing rods on 16-in. centers. These rods are tack welded to the steel framing. In some instances 1¼ in. round or square reinforcing rods were welded to the edges of horizontal members in the framing, to bring them to the required wall width, and the ½-in. rods welded to these. Welders worked from a movable scaffold resting on the floor and skidded around as required in applying furring rods to the ceiling and higher portions of the walls. Steel was cut with an oxyacetylene torch and any burrs removed from the structural beams with a cold chisel. The heavier beams were hoisted to place with tackle, but the furring rods and other light pieces were held by the welder's helpers.

The rear wall of the building is made up of two large swinging steel doors on cross-welded frames, and one 15-ft. solid wall panel. An unusual feature of the doors is their stability and ease of operation. Top and bottom hinges are made of Model-A Ford hubs and spindles, cut off and welded on a small piece of plate, which is in turn welded to short sections of 4x4 angle welded to the framing. The hinges are attached to the doors by pairs of steel bars welded in place. Pins holding the bottom corners of the doors, when closed, are attached by a chain and slip into holes in a 20-in. section of 2-in. pipe laid horizontally and fastened to the concrete floor with two pins welded through the pipe and leaded into the concrete. This does not interfere with moving heavy equipment in and out of the building, and the holes do not fill up as they would if sunk in the concrete.

For loading and unloading material from trucks, an improvised stiff-leg derrick is equipped with a bottom hinge made from an altered tractor track roller, countersunk in the concrete floor. A 5- and a 3-ton hand hoist are also available, moving on an overhead track which extends the length of the shop and 16 ft. outside the rear doors. Used 4-in.-dia. pipe was cut and welded into posts and stiles for an 8-ft. fence along the material yard connecting with a rear corner of the building. Left-over sheet metal was bolted to this framework to make the fence. Access to the rear of the yard is through two 12-ft.-high gates made into an ornamental framework by smaller pipe cut and welded. These gates, and similar ones on the opposite side of the building, move easily on an overhead grooved track.

Simple Load Test for Concrete Floor System

Earl B. Bailey
Architectural Engineer, Office of the Constructing Quartermaster
Panama Canal Department

Contents in Brief—With laboratory tests indicating sub-specification concrete strength, a job-built lever system was used to measure deflection of slab or beam under twice the design live load.

To TEST concrete slabs, when test cylinders show the strength of the concrete is considerably below specification requirements, a simple method is being used with success by the Constructing Quartermaster of the Panama Canal Department of the Army. The required equipment can be easily built in any carpenter shop.

The slab in question is loaded to twice its design live load with bags of cement. Two adjacent bays are loaded for a test and the load is extended out around the columns to the quarter points of the adjacent spans.

The deflection is measured by wooden deflection needles placed under the middle of the slabs or beam being tested. This deflection needle consists of a beam 7 ft. long resting on a knife-edge fulcrum placed 1 ft. from one end. A vertical strut extends from the end of the 1-ft. lever arm to the bottom of the slab above (see illustration). The 6-ft. lever arm serves as a pointer, and the movement is six times the deflection of the slab. Recording paper is tacked to a background at the end of the pointer and the arc of the pointer exactly 6 ft. from the fulcrum scribed on the recording paper.

Taking a reading consists of making sure the pointer is hanging clear

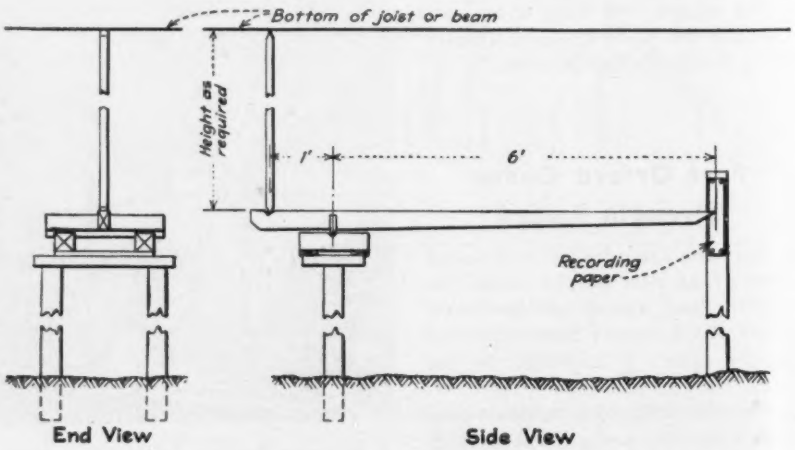


Fig. 1. Arrangement of deflection needle test apparatus used under slab on beam subject to twice the design live load.

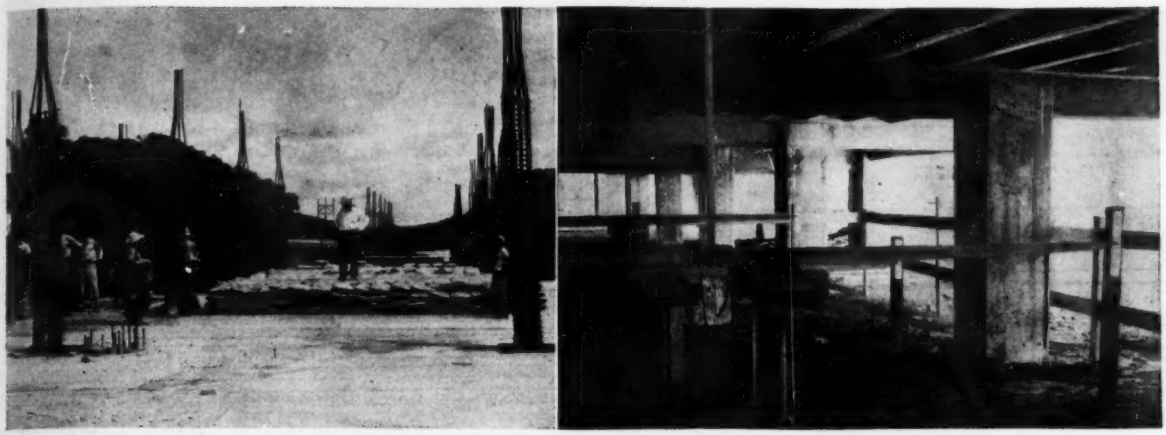


Fig. 2. Loading a panel slab with sacks of cement (left) up to twice the design load. Resulting deflection measured (right) with readings made during a no-load, loaded and unloaded cycle.

and everything in alignment, and then drawing a line on the recording paper across the arc with a straightedge laid on top of the pointer. The amount of movement of the pointer is then measured along the arc with an engineer's scale. There is no play in the instrument since the weight of the pointer keeps everything tight and in compression. A movement of the pointer of 1/50 in. is easily measured and indicates a .0033-in. deflection.

The tests are conducted with as much accuracy as possible and a complete log of the tests kept, recording the time readings are taken and the location of all cracks as they appear, and any other contributory data so that it may be used as legal evidence if necessary.

The load is allowed to remain in place for 24 hr., during which time a constant watch is kept and deflection noted. The load is then removed and the amount of recovery noted. The slab is allowed to rest for 24 hr. and the recovery again noted. This last reading concludes the test.

The schedule of readings is as follows:

0 Reading—No load
1 Reading—½ load, 1st panel
2 Reading—Full load, 1st panel
3 Reading—½ load, 2nd panel
4 Reading—Full load, 2nd panel
5 Reading—Full load after 24 hours
6 Reading—Load half removed
7 Reading—Load entirely removed
8 Reading—24 hr. after starting to unload
9 Reading—24 hr. after finishing unloading

The slab is considered to have passed the test if there are no signs of failure and the deflection and lack of recovery do not exceed the maximum allowed by the American Concrete Institute in "Building Regulations for Reinforced Concrete". These regulations allow the following:

"The structure shall be considered to have passed the test if the maximum deflection at the end of the twenty-four hour period does not exceed the value of D as given by the following:

$$D = \frac{.001\,L^2}{12t}$$ in which

L = span
t = total depth of the slab or beam and
D = maximum deflection, all expressed in the same units.

If the deflection exceeds the value of D as given in the formula, the construction shall be considered to have passed the test if within twenty-four hours after the removal of the load the slabs or beams show a recovery of at least seventy-five percent of the observed deflection."

The recording papers are removed at the end of the test and preserved as a permanent record.

Army Camps Bring Problems to Louisiana City

ARMY CAMPS and defense industries may bring "boom town" prosperity to many communities, but experiences of one Louisiana city show this is accompanied by mounting problems involving municipal public works services and facilities. The Louisiana city is Alexandria, surrounded by three training camps containing 125,000 soldiers. In addition, the city's normal population of 27,000 has been swelled by thousands of workmen completing construction of two of the camps and enlarging the permanent Camp Beauregard.

According to information received by the American Municipal Association, surfaced streets in Alexandria have been cut through by traffic, resurfaced, and cut through again. City, parish and state face the job of widening streets and roads. To meet traffic problems, one-way streets were designated, traffic lights added, and new restrictions placed on parking. State and military police work with city officials in handling problems of patrol and traffic regulation.

For fire protection, the city put a water pumper truck at the disposal of Camp Beauregard. The crew of men handling garbage has been doubled, and the city disposal plant handles without charge most of the waste of one of the camps.

In November, 1939, building permits in the city called for $31,000 of new construction. In November, 1940, building permits amounted to $73,000, and in January, 1941, to $216,000. Of the last sum $135,000 was for dwelling houses and apartments. The city is now pushing for federal housing assistance in the form of a project for 1,250 housing units.

Taxes have not been increased, and the city-owned utilities apparently have borne the cost. New water connections are made daily and old users are taking greater volume. Demands for light and gas have increased at equal or faster pace. Two of the army camps purchase all their gas from the city plant. Increased demands for service have called for an increase in plant facilities.

From Field and Office

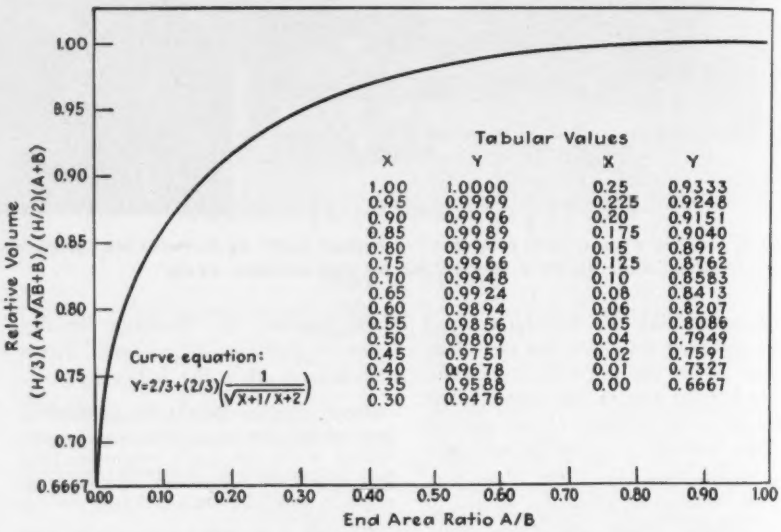
Working problems and time-saving methods for engineers and contractors

Calculating Earthwork Quantities

In many engineering offices there arises periodically the question of degree of accuracy of computation of quantities by the average-end-area method. Use of the more accurate frustrum of a cone formula is tedious and generally unwarranted.

The accompanying graph shows the relation between volumes computed by the two methods, indicating the of quantities by the average-end-area area computation. The graph quickly supplies the factor for correction, and saves much needless work.

In the formulae shown, A represents the lesser of two parallel end areas and B the greater. H is the perpendicular distance between the two areas. As indicated on the graph, the horizontal, or X, axis represents the ratio between the two given end areas. With this ratio as an argument, the percentage relation between computed volumes for the given figure, as determined by the two different methods of computation, is found on the vertical, or Y, axis. In order that the curve may be quickly reproduced on a scale suitable for office use, values for the two coordinates are given for several points.—WILLIAM E. CARRUTH, *Carmel, N. Y.*



Graph makes possible rapid correction for error in average-end-area method.

Folding Manhole Guardrail

To keep children and inquisitive people from following water department men into understreet valve vaults on the large feeder lines, folding manhole guardrails of the type shown in the accompanying photograph have been provided at certain entrances by the Denver Municipal Waterworks.

The railing is made of ½-in. pipe and fittings. The three legs along the curb side of the manhole are flattened and secured by ordinary hinges welded to the manhole frame. The end pieces swing on ¾x½-in. tees slipped over the side legs.

When not in use, the manhole guardrail lies flat under the hinged steel cover.

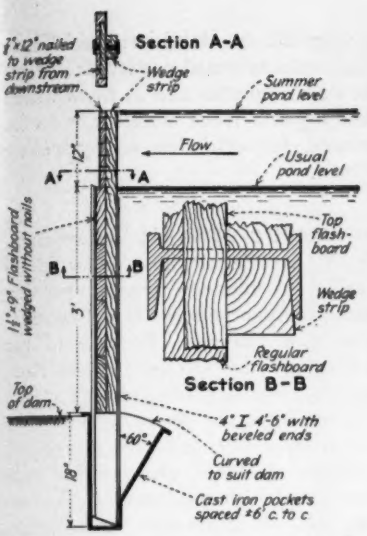
Self-Cleaning Flashboard Pocket

The flashboard pocket shown in the accompanying sketch is self-cleaning, when water is flowing over the dam. A foot or more overflow will set up an eddy in the pocket raising any contained sand or silt and washing it down-stream. This same action prevents the pocket from being filled with sand or silt during high water. In low water, the pocket may easily be cleaned with a small shovel cut to fit and slightly scooped.

As no machine work is required on this pocket, it may be made from a low grade of hard cast iron. A complete casting is more economical than it is to form a pocket in the concrete and set a cast-iron collar.

The boards should be too light, rather than too heavy, so that breakage will be positive at the desired overflow. The top board should go out when there is a slight rise in the river, the height of such a rise being controlled by the water rights above the dam. As the boards are not nailed, except the top one, they may be used to regulate the flow line in the pond by removing one or more rows. The boards may be handled from a row boat, or from the top of the dam, in time of low water.

Ice will lift the boards, but it is



Self-cleaning crest pocket for footing flashboard supports on concrete dams.

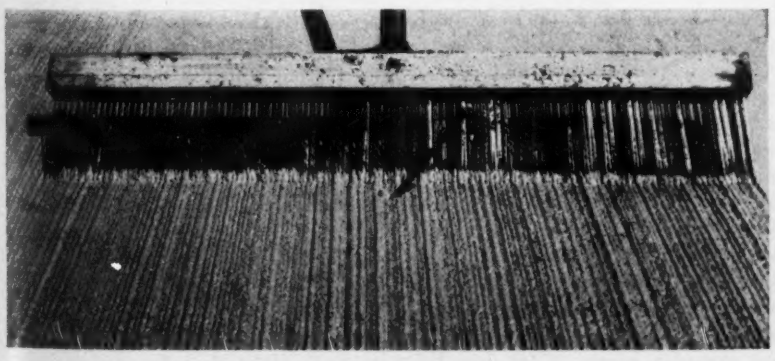
customary to remove them prior to the winter floods, unless an early flood makes it impracticable. High water will bend the I-beam posts so that they have no value except as junk. Also it is more economical to replace the boards than to attempt to salvage them below the dam. By changing the proportions to suit, the pocket may be modified to allow the use of 3-in., or 5-in., I-beam posts. A total height of 5 ft. is the economical limit.

This type of flashboards has been in use on the dam at Essex Junction, Vt., since 1917, and also at the Gorge, Winooski, Vt., and at Stone Pond, Glover, Vt.—C. E. NIGHTINGALE, *Old Greenwich, Conn.*

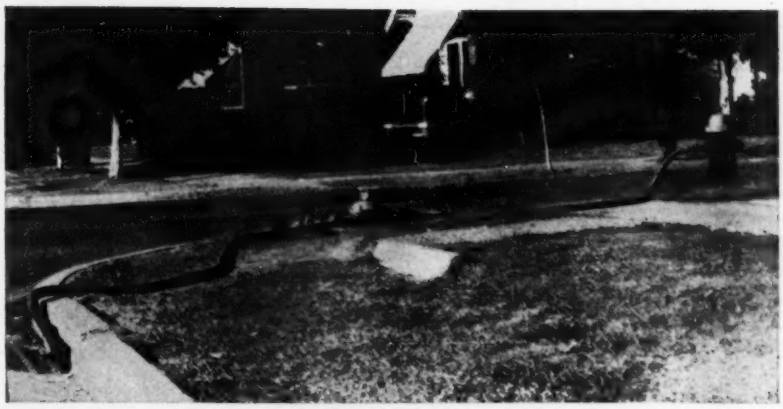
Non-Skid Concrete

Brushes with steel bristles, stroked transversely on freshly-poured concrete pavement, make grooves just right to give a maximum of non-skid quality to the wearing surface and to diminish night glare, according to experience on Oregon state highways. Since this plan was first tried some two years ago, the practice has been to finish off all Oregon concrete pavements in this way and results are reported to be highly satisfactory.

Ordinary brooms, lacking the stiffness of metal, do not give satisfactory results and surfaces finished with them are not nearly so "non-skid" as when the steel bristles are used. With the steel, the grooves tend to be continuous and are sharply defined; thus they aid in drainage as well as in affording grip for tires. The grooves eliminate the water film on the surface which acts as a lubricant under the tires and, at night, reflects the lights of oncoming vehicles.



Close-up of the sharply grooved surface typical of results with the steel bristles. Pencil in front of brush indicates scale.



Connection Dodges Traffic

Temporary water lines, laid across the pavement and protected by loose earth or pairs of planks strapped together, slow down traffic and form an unnecessary hazard. In Houston when construction water is to be obtained from a fire hydrant across a busy thoroughfare from the building site, the temporary connection shown in the accompanying picture is made with a heavy hose. Threaded into adjacent sewer openings and carried below the pavement to emerge at the far side of the street from the hydrant, the connection affords a steady flow undisturbed by the passage of even, the heaviest vehicles. — Elton Sterrett, Houston, Texas.

Reducing Cable Wear

Brown & Root, Inc., contractors for the repairs to "East" and West jetties at Sabine, Tex., are using "fair lead" devices such as the one below to reduce wear on barge anchor cables. Made cheaply from spare parts, the installation is expected to double a cable's life.—WILLIAM L. RAVENSTEIN, *Port Arthur, Tex.*

Notes on Sewage Disposal

A monthly summary of current developments conducted by Willem Rudolfs

SEWER RENTAL STATUS—Service charges for the use of sewerage systems are made by 170 cities, nine of which imposed the levy for the first time in 1940, according to a survey made by the International City Managers' Association. The quest for additional municipal revenues is given as the chief reason for the adoption of sewer rental charges.

In 1940, revenues from sewer rentals in the reporting cities ranged from little more than $1,000 to well over $1,000,000, according to the survey, which appears in the association's 1941 Year Book. Detroit collected $1,130,373 in the last eight months of the year. Large revenues were collected also by Buffalo—$803,987; Seattle—$567,000; Minneapolis—$484,873; and Columbus, Ohio—$408,685. A number of cities in the 10,000 to 25,000 population group, which includes more than two-thirds of the cities making sewer charges, obtained close to $50,000 apiece from the rentals.

The cities use one or more of six different bases of charge. Cities over 50,000 population rely almost exclusively upon metered water consumption or a percentage of the water bill. The cities between 10,000 and 25,000, however, use a wider variety of bases—a fixed percent of the water bill, number of sewer connections, type or kind of property, number of plumbing connections, and metered water consumption. One city combines four bases and others use two or three.

SLUDGE DIGESTION COST—Heated digestion tanks obviously are capable of handling larger quantities of sludge than unheated tanks. It is also evident that control of heated tanks is easier, less liable to produce difficulties and odor nuisances, but the cost may be materially higher. A comparison of unheated tank digestion in the same district where heated digestion is now employed was given by Jenkins (*Proc. Institute of Sewage Purification*, Part II, 1940). The population draining to the Tame Valley Works (England) was 900,000 in 1923 and 1,055,000 in 1938. The comparative cost per ton crude sludge (containing 90 percent moisture), including interest on capital cost, labor, power and air drying, was 12.74 pence in 1923 and 9.80 pence in 1938. The reduction in actual cost in spite of 13 percent higher labor cost appears to be due to more sludge handled, the use of heated tanks, reduced charges for power and less labor required with better digestion.

"AN UNMISTAKABLE SIGN of improved efficiency and reliability of sewage purification works is the increasing use of sewage effluents as cooling water in electric power stations and for trade purposes." H. C. WHITEHEAD, *President, Inst. Sewage Purification, England.*

TEMPERATURE AND FILTER EFFICIENCY—The effect of temperature on the activities of trickling filters is well recognized, and is exemplified by the higher degree of purification in summer as compared with winter conditions. A series of experiments conducted on eight model filters by Wilson and Hamlin (*Annual Report*, City of Johannesburg, So. Africa, 1940) showed that the benefit of temperature was marked up to 95 deg. F., but that at 100 deg. F. the benefit disappears.

At that temperature and above, purification and nitrification were seriously diminished. At 110 deg. F., only traces of nitrification were recorded, while the relative stability and B.O.D. figures showed serious deterioration. At 120 deg. F. oxidation ceases almost entirely, with high B.O.D. and complete instability. The authors conclude broadly "that purification falls off greatly and nitrification virtually ceases at 90 deg. F." However, if the temperature is reduced to below 85 deg. F., nitrification quickly reestablishes itself. These observations are of particular interest in warm climates and in cases where hot organic trade wastes are to be treated for oxidation on sprinkling filters.

HYPERBOLIC WEIR—At Lackawanna, N. Y., an electric flow meter is installed to measure sewage passing through hyperbolic weirs in two separate flow channels. Because of the advantage the electric transmitting system gives in placing the recording instrument at any desired location, its application extends to any flow-measurement problem where water contaminated with solid matter prevents the use of orifice-type instruments, according to the Cochrane Corp. of Philadelphia, who furnished the meter. The single recording-and-integrating instrument measures the total flow in two channels. The proportional hyperbolic weirs produce a flow directly proportional to the head above the weir base.

Solids in the sewage total 1,800 parts per million. A series of bars in the approach channels stop the suspended material that might clog the weir notches. This material is removed with a rake and the frequency of cleaning can be read on the chart as momentary flow increases.

SEWER RENTAL HISTORY — Inspired by the comment in these columns (Feb. 27, 1941, p. 351) that Fayetteville, N. C., was one of the first communities in this country to adopt a sewer rental charge, Earl Devendorf, assistant director, division of sanitation, New York State Health Department, writes:

"As chairman of the Committee on Sewer Rental Laws and Procedure of the American Society of Civil Engineers, I received reports from various public works departments throughout the United States in reply to a questionnaire which was sent last year, and among these was the following:

" 'Town of Natick, Mass. Information submitted by the Department of Public Works—date of ordnance, June 9, 1894—sewer charge based on water consumption with minimum rate of $1.25 per quarter.'

"There are others also that antedate the Fayetteville, N. C., ordnance." (Editor's note: *See also remarks by M. N. Baker*, ENR, *April 10, 1941, p. 557.*)

ALUMINUM, DEFENSE, AND YOU

ALCOA

2

ANOTHER MONTH!

DEFENSE IS GETTING its aluminum; but priorities are in effect, and many regular users of aluminum are having to do without.

YOU, SIR, may be one of those who have to wait. It *is* a hardship. It *is* awkward. Customer by customer, we are intimately and acutely aware of the dislocation of plans caused by this temporary shortage of metal.

BUT YOUR ALUMINUM *is* on the way. It is a promise.

IN MARCH we produced more than 44,000,000 pounds of new metal. That is 63% more than in the average month of 1939. Enormous new plants, already completed, made this possible.

STILL MORE producing units are coming in as fast as brick and steel and equipment can be put into place. We are getting superb co-operation from suppliers. A capacity of 60,000,000 pounds a month is definitely programmed, by day and date, at this writing.

PRAY FOR RAIN. Good precipitation assures the water power that we need to keep breaking production records. Production of aluminum depends on getting the power.

TWO POUNDS OF ALUMINA are needed for each pound of aluminum. We are jumping Mobile, Ala., alumina refining facilities from a million to 2,200,000 pounds a day. That requires among other equipment, 64 precipitating tanks, 24 feet in diameter, standing 80 feet high. They would hold all the wheat grown in Wisconsin.

FORGING EXPANSION is an example of swift increase in fabrication capacity. On the first of January, 1940, we had 47 hammers, presses, and upsetters. Today: 110. Increase: 134%. We await delivery on 26 more units, which will make a total of 136, an increase of almost 200%. Falling weight of the hammers alone is over three times that of January 1, 1940.

ROLLING CAPACITY for wire, rod, bar, and shapes has been increased 2½ times. Expansion in sheet rolling capacity was reported to you last month.

COMPARED TO THE fifty-some years it took the use of aluminum to reach 1939 levels, you might say that the industry is having to more than duplicate itself over the week end.

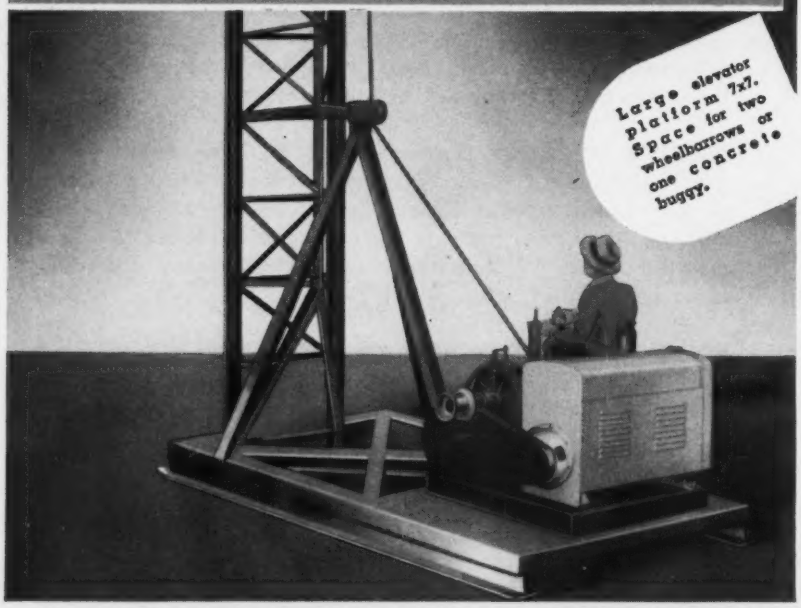
THESE PARAGRAPHS are factual evidence of our determination that no one shall have to forego the things aluminum does best one minute longer than we can help.

IT IS A PROMISE.

ALUMINUM COMPANY OF AMERICA

Lick HIGH HANDLING COSTS WITH THE NEW AMERICAN Portable MATERIAL ELEVATOR
Operated with an AMERICAN Model 35 One Drum Gasoline Hoist with 21 H. P. 4 cylinder gasoline engine.

Don't let high material handling costs eat up your profits. The AMERICAN Portable Material Elevator makes economical operation possible even on the smaller jobs. This compact tower and hoist unit can be set up and working in less than two hours. Short moves on the job are made without lowering the tower. Avoid the risk, delay and needless expense of wooden towers. Speed up construction and increase your profits by handling your building materials the modern way.



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MEN AND JOBS

WALTER C. SMITH, city manager, and JAY E. HENRY, director, department of public works, City of Wheeling, W. Va., both reserve officers in the U. S. Army, have been called for active duty at Atlanta, Ga., and Columbus, Ohio, respectively. ROBERT L. PLUMMER has been appointed city manager during the absence of Mr. Smith, and WALTER STEGMAN replaces Mr. Henry.

HOWARD CAPPER of Camp Hill, Pa., once before borough engineer for Camp Hill, has been renamed to that position to succeed HARRY A. DEWIRE of Harrisburg. Mr. DeWire, who was engineer during the construction of a sewer system, will continue with the borough as sewer engineer.

GEORGE H. DENT has been appointed district engineer for the Asphalt Institute with offices in the Transportation Building, Washington, D. C., effective May 1. An alumnus of the University of Maryland, Mr. Dent has served with the State Roads Commission of that state from 1924 to 1940. In 1941 he received the appointment of paving engineer for the Civil Aeronautics Administration for the 13 states comprising the North Atlantic division.

FRED MULLINEAUX of Wilmington, Del., has been appointed resident engineer of the U. S. Army Engineer Reservation in Atlantic City, succeeding MAYLIN H. GREASER, who will enter private employment.

PHILLIP S. DAVY, who was associated with the firm of Frank J. Davy & Son, consulting engineers of LaCrosse, Wis., has been called to active duty with the sanitation division of the Quartermaster Corps. JOHN E. BERNHARD, who was also associated with the Davy firm as chief draftsman, has left for Washington, D. C., as engineering draftsman with the Ordnance Department.

I. L. JOHNSON, staff engineer for Donald R. Warren, Los Angeles, sailed April 18 to report to the Commandant of the 14th Naval District, Pearl Harbor, as a lieutenant in the Civil Engineers Corps, U. S. Navy. Until recently Mr. Johnson was principal structural engineer on the design of the magnesium plant being built near San Jose, and on marine structures at Long Beach, Calif.

HOMER A. HOLLINGSHEAD, assistant highway engineer with the Illinois division of highways for a number of years, has been called to active duty, effective May 1. He is a major in the Corps of Engineers. He will report to the Engineer School at Fort Belvoir, Va.

STEPHEN WILDEMAN, senior engineering draftsman, recently with the Quartermaster Corps of the War Department, at Chanute Field, Ill., has been transferred and promoted to principal engineering draftsman in charge of drafting at the Kankakee Ordnance Works, Joliet, Ill. Mr. Wildeman has served the War Department for six years and was formerly associated with the U. S. Engineers at Rock Island and Peoria, Ill.

MAJOR GENERAL JAMES A. WOODRUFF, commanding the First Corps Area with headquarters at Boston, Mass., will retire fom active service on June 30 next. General Woodruff, who will reach the statutory retirement age of 64 on June 19, 1941, was born in Fort Shaw, Montana, and was graduated from the U. S. Military Academy in February, 1899. He served for many years as an officer of the Corps of Engineers. His early service was as officer in charge of various military surveys in the Philippine Islands. Later he served as an instructor in civil and military engineering at the U. S. Military Academy.

ROBERT R. HUBBARD, senior engineer in charge of street and bridge maintenance in the city engineering department of Seattle, Wash. and CLARK ELDRIDGE, bridge engineer for the Washington state highway department, have been appointed to positions with the Navy Department on the island of Guam.

C. E. ANDREW, chairman of the board of consulting engineers for the Washington State Toll Bridge Authority on construction of the Lake Washington pontoon and Tacoma Narrows suspension bridges, has been appointed bridge engineer for the Washington state highway department, succeeding CLARK ELDRIDGE. His principal duties for the present will be in connection with the insurance settlement on the Narrows bridge; he will also continue studies in connection with reconstruction of that bridge.

E. W. SWAN has been appointed resident engineer at Wallace, Idaho, for the Idaho Bureau of Highways, succeeding FRED DOW. Mr. Swan has been with the department 12 years.

JOEL B. COX, engineer with the McBryde Sugar Co. on the island of Kauai since 1923, has been appointed assistant professor of engineering at the University of Hawaii, Honolulu, T. H. Mr. Cox will fill the position left vacant by JOHN MASON YOUNG, who has retired after 32 years of teaching at the university.

BEN T. COLLIER, Clarksdale, Miss., county engineer, of Coahama County, was recently appointed to the State Board of Examiners for Professional Engineers for the state at large.

CAPT. JAMES A. OSTRAND, JR., U. S. Engineer Corps, has been ordered from West Point to duty in Hawaii.

HARVEY KRUSE, formerly superintendent for Healy Subway Const. Co. in charge of the Dearborn St. section of the Chicago subway, has joined the combined firm of Guy F. Atkinson and Geo. Pollack, contractors on the new naval base at Long Beach, Calif. He will be general superintendent on the construction of the dry-dock.

CAPT. LAWRENCE T. SMITH, U. S. Engineers, reserves, has been named chief, military intelligence section, at Camp Grant, Ill. He was formerly resident engineer for the Chicago Park District.

LT.-COL. LACEY V. MURROW, former Washington state highway director, sailed for Lisbon recently on his way to England to conduct a special study of flight strips and highways under war conditions.

M. R. HOFFMAN, area engineer for WPA at Minot, North Dakota, has been promoted to the position of assistant state director of the division of operations with headquarters at Bismarck.

V. R. PARKHURST, Topeka, Kan., has been engaged by the Widmer Engineering Co., architects and engineers, for Fort Riley defense projects, to prepare plans for levees and dikes.

LT. ALBERT J. BARTOS, of Omaha, Neb., reserve officer and engineer, has been ordered to active duty at Fort Belvoir, Va.

H. E. BAILEY, Perry, Okla., who has been a member of the Oklahoma State Highway Commission for the past two years, was recently named city manager of Oklahoma City, succeeding W. A. QUINN, who resigned. Mr. Bailey is an engineer graduate of the University of Tennessee and has had 20 years of engineering practice.

F. A. RODY, for four years engineer for Jewell County, Kan., has been named county engineer for Pratt County with headquarters at Pratt.

EARLE CAPEL has been named acting district engineer for the State Highway Department of Iowa with headquarters at Sioux City, replacing E. W. DUNN, who is working on the army barracks at Rolla, Mo. Capel was formerly assistant district engineer.

CHARLES A. PINE, former Leavenworth, Kan., city engineer, has gone to Alexandra, La., to accept a position in the con-

(*Continued on page* 100)

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Heavy Duty

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that especially equips them for extremely heavy construction and industrial service.

Compare AMERICAN Heavy Duty Wire Rope Blocks with any other make. Notice how much heavier the pins and axles are than the usual block practice. Notice, too, how the thick shell plates extend well beyond the sheave flanges to protect them against chipping and breaking. Forged steel hooks and shackles are oversize and properly proportioned to put the most metal where the heaviest stresses fall.

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WOLMANIZED LUMBER

(*Continued from p.* 99)

struction of Camp Dickinson army cantonment.

HERMAN LANGHELDT has been appointed maintenance engineer by the Wyoming State Highway Department and will have his headquarters at Rock Springs. He succeeds WILLIAM E. SUTTON, who has been transferred to Cheyenne as chief of the eastern division.

PAUL J. MONTGOMERY, Topeka, Kan., who has been employed on the Wyandotte County Dam near Kansas City, has been promoted to junior engineer on defense base work in Bermuda. Formerly, he was employed in the soil laboratory of the Kansas State Highway Department.

HAROLD H. PARKS and MERRITT L. ANDERSON, members of the Denver staff of the Public Roads Administration, have gone to Panama, where they will work on a special assignment for a defense highway across the Isthmus of Panama.

COL. JAMES H. GRAHAM, dean of the University of Kentucky College of Engineering for the last six years, will leave for Washington for active duty in the War Department, Constructing Quartermaster's office. Col. Graham has been granted a three months' leave of absence from the University for this duty, and will be given a longer leave if necessary. During his absence, Assistant Dean W. E. FREEMAN will be in charge of the Engineering College. Col. Graham is to serve under Gen. Brehon B. Somervell, with whom he served in France during the World War.

The shareholders of the Hadley-McHaffie Construction Co., Ltd., Hamilton, Ontario, have elected CHARLES A. BIRGE of Toronto to act as president during the absence of CAPT. CHARLES E. HADLEY. Capt. Hadley is on active service with the Canadian military forces and has recently arrived in England.

JOHN R. MACQUEEN has been appointed Cook County engineer with headquarters at Grand Marais, Minn., to serve in the absence of HARLO P. BESCHENBOSSEL, who has been called to active duty.

HARRY G. HANSON will be acting director of the division of sanitary engineering for the North Dakota Health Department during the absence of LLOYD K. CLARK, director, who has been ordered to a year's active service with the army.

JOHN H. HARMON, El Dorado, Ark., has been appointed district engineer of Highway District No. 7, Arkansas State Highway Department, with headquarters at Camden.

(*Continued on p.* 112)

Want to see *two* sets of *identical* twins?

When Dixon says it's an HB, you can depend on its being just that. Two HB's are identical twins. The same is true of any given degree throughout the range of 17 degrees. Such uniformly accurate grading is made possible by *Typhonite*—whose particles are of minutely even, controlled size—the size found best for lead making. *Typhonite*, product of an exclusive Dixon process, is responsible for the smoothness of *Typhonite* Eldorado leads as well as their opaque lines. Your dealer will supply you with Dixon's *Typhonite* Eldorado.

PENCIL SALES DEPARTMENT 227-J5, JOSEPH DIXON CRUCIBLE COMPANY, JERSEY CITY, N. J.

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

FLOOD PROTECTION
PADUCAH, KY.

OWNER: U. S. Engineer Office, Louisville, Ky.

PROJECT: Work to be done consists of construction of earth levees, steel sheet piling and concrete walls, drainage and movable closure structures, toe drains, sewers, concrete gutters, manholes, catch basins, and appurtenant works in northeastern part of city of Paducah, Ky. (Section B, Unit 1). Protection works begin at end of existing levee, near Mill and Meyers Streets, and extend downstream along bank of Ohio River to Tennessee Street. Sloughs, old pits, ditches or depressions between right-of-way limits and base of embankment, both land and riverside, to be filled to natural ground line.

CONDITIONS: Rights-of-way and borrow area for constructing embankment, walls, etc., to be furnished without cost to contractor. Contractor to furnish all other material. Work to be completed within one year, and without interference to other contractors. Rail, highway and water transportation facilities available. Contractor to maintain traffic, or provide detours for highways; maintain utility services; and to interfere with railroad traffic and manufacturing operations in vicinity as little as possible. Wage rates are: skilled labor, $1.00 to $1.50; semi-skilled, 50 to 75c.; and common labor, 50c. per hr.

BIDS: Thirteen bids were opened February 11, 1941, ranging from the contract low of $346,284 to $549,391. Engineer's estimate $429,461.

1. C. E. Carson Co., Chicago, Ill. (contract) $346,284
2. A. G. Ryan & Sons, Evansville, Ind. 385,458
3. Foster & Creighton Co., Nashville, Tenn. 403,274
4. Drainage Contractors, Inc., Detroit, Mich. 406,038
5. Hoeffken Bros. Supply & Constr. Co., and G. E. Tillman, Centralia, Ill. 418,822
6. R. B. Potashnick, Cape Girardeau, Mo. 419,683
7. The Kramp Constr. Co., Inc., Milwaukee, Wis. 444,236
8. Regenhardt Constr. Co., Cape Girardeau, Mo. 445,809
9. Midland Constructors, Inc., Chicago, Ill. 472,929
10. Fitz Simons & Connell Dredge & Dock Co., Chicago, Ill. 475,299
11. L. B. Strandberg & Son, Chicago, Ill. 492,180
12. Stiers Bros. Constr. Co., St. Louis, Mo. 499,929
13. J. B. Michael & Co., Memphis, Tenn. 549,391

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Levee embankment	54,000 c. y.	$0.60	$0.45	$0.35
2. Rolling, for each 3 add'l. passes	3,000 sq.	.02	.02	.14
3. Stripping	5,400 c. y.	.50	.30	.20
4. Common excavation	19,000 c. y.	.40	.75	.71
5. Backfill, compacted	10,600 c. y.	.50	1.00	.50
6. Concrete	13,880 c. y.	12.90	15.00	16.80
7. Reinforcing steel	840,000 lb.	.04	.044	.045
8. Steel sheet piling	790,000 lb.	.04	.045	.0475
9. Structural steel	7,300 lb.	.175	.25	.15
10. Miscellaneous metals	14,100 lb.	.30	.30	.42
11. Copper	17,200 lb.	.50	.35	.35
12. Vault door and frame	14 ea.	105.00	100.00	230.00
13. Seal trench filler	325 s. f.	.50	1.00	1.00
14. Hand placed riprap	1,025 c. y.	6.00	4.00	5.00
15. Gravel blanket	760 c. y.	1.50	2.00	2.00
16. Raise, relocate, replace railroad tracks	L. S.	500.00	2,900.00	5,550.00
17. 8-in. corrugated iron pipe	45 l. f.	2.00	3.80	2.00
18. 18-in. corrugated iron pipe	45 l. f.	4.00	3.50	3.75
19. 66-in. corrugated iron pipe	157 l. f.	17.50	17.00	20.00
20. Galv. iron seep ring	520 s. f.	1.50	1.25	1.60
21. 6-in. wrought iron pipe	24 l. f.	3.50	4.00	4.00
22. 8-in. wrought iron pipe	125 l. f.	4.50	5.00	4.60
23. 12-in. wrought iron pipe	58 l. f.	9.00	12.00	6.50
24. 18-in. wrought iron pipe	122 l. f.	15.00	15.00	10.00
25. 30-in. wrought iron pipe	26 l. f.	95.00	40.00	25.00
26. 6-in. cast iron pipe	100 l. f.	3.60	3.00	2.00
27. 8-in. cast iron pipe	52 l. f.	4.00	5.00	3.50
28. 24-in. cast iron pipe	20 l. f.	100.00	20.00	25.00
29. 8-in. automatic drainage gate	1 ea.	20.00	20.00	21.00
30. 18-in. automatic drainage gate	2 ea.	40.00	40.00	60.00
31. 66-in. automatic drainage gate	1 ea.	450.00	550.00	550.00
32. 6-in. sluice gate	1 ea.	140.00	200.00	100.00
33. 8-in. sluice gate	1 ea.	175.00	225.00	125.00
34. 12-in. sluice gate	1 ea.	250.00	275.00	180.00
35. 24-in. sluice gate	1 ea.	600.00	575.00	500.00
36. 30-in. sluice gate	1 ea.	700.00	650.00	600.00
37. 8-in. toe drain	4,560 l. f.	1.50	1.75	2.00
38. 12-in. toe drain	820 l. f.	2.00	2.50	2.75
39. 6-in. vitr. sewer pipe	26 l. f.	.50	1.25	.75
40. 8-in. corr. iron pipe sewer	930 l. f.	2.00	2.50	1.40
41. 12-in. corr. iron pipe sewer	55 l. f.	2.50	3.75	3.00
42. 18-in. corr. iron pipe sewer	33 l. f.	4.00	5.00	4.00
43. Concrete gutter	360 l. f.	1.00	1.25	1.00
44. Pipe conn. and valve sta. 52+30	L. S.	60.00	270.00	140.00
45. Pipe conn. and valve sta. 81+37.8	L. S.	75.00	270.00	110.00
46. Relocate 6-in. vitr. pipe	L. S.	50.00	150.00	55.00
47. Pipe conn. through wall	L. S.	150.00	650.00	600.00
48. Pipe conn. through wall	L. S.	100.00	750.00	700.00
49. Misc. pipe conn. through wall	L. S.	400.00	1,575.00	325.00
50. Remove exist. conc. structures	350 c. y.	7.50	3.00	2.00
51. Remove exist. pipes	950 l. f.	1.00	1.50	.25
52. Connections to exist. drains	15 ea.	50.00	50.00	20.00
53. Shoring left in place	1 Mbm.	50.00	30.00	50.00

SEWAGE PLANT BUILDINGS
CHICAGO, ILL.

OWNER: Sanitary District of Chicago, Chicago, Ill.; W. K. Trinkhaus, engineer; F. L. Finlayson, architect.

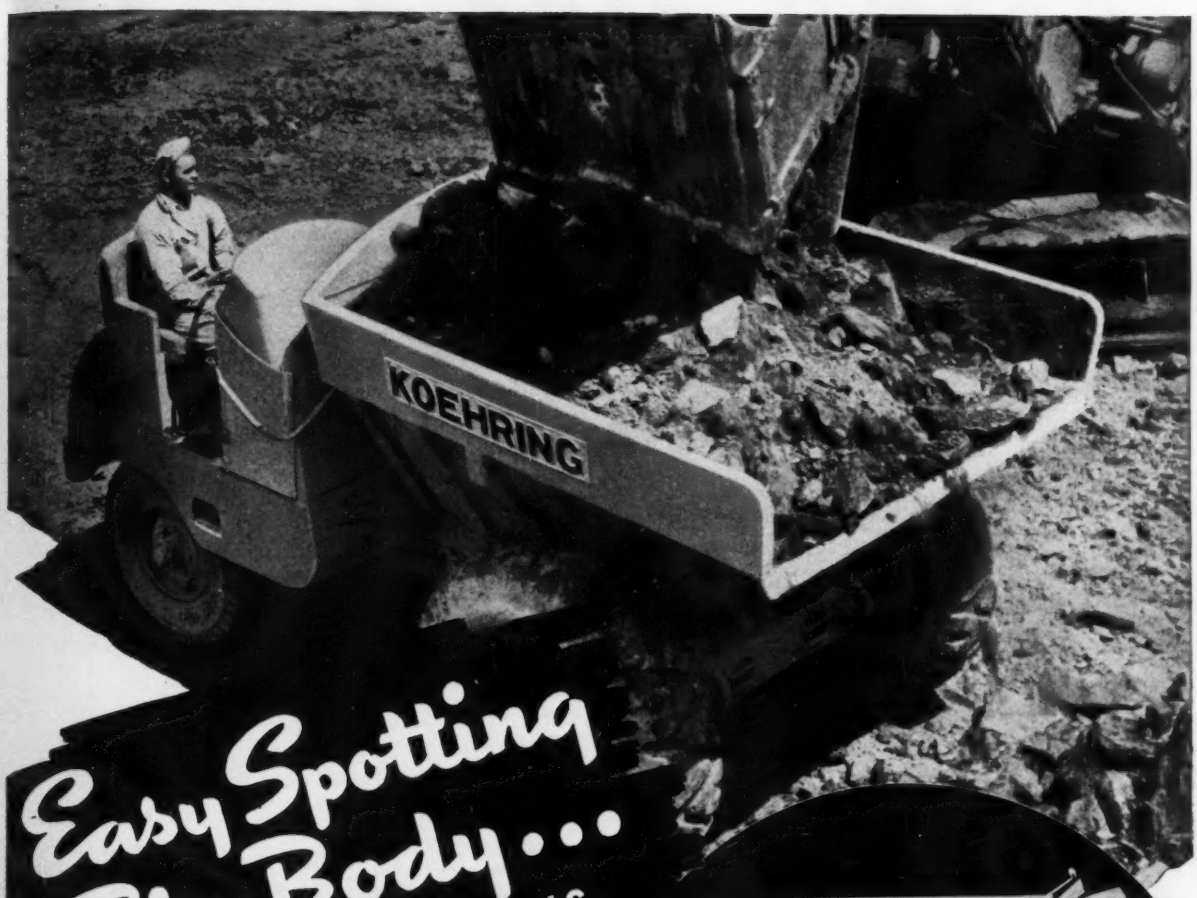
PROJECT: Construction of dried-sludge building, conveyor tunnel extension, elevator tower, foundations and superstructure, conveyor bridge, track work, drainage, and miscellaneous construction in connection with Stickney Sewage Disposal Plant (Division G), Pershing Road and 52nd Avenue, Cook County, Ill.

CONDITIONS: Contractor to furnish all materials, plant and labor. Rail and highway transportation facilities available. Wage rates are in accord with existing Chicago union scales.
BIDS: Twelve bids were received February 20, 1941, ranging from the contract low of $172,961 to $261,765.

LIST OF BIDDERS:

1. Marsch Constr. Co., Chicago, Ill. (contract) $172,961
2. George Cassidy & Son, Chicago, Ill. 177,318
3. Michael J. McDermott Co., Chicago, Ill. 181,598
4. Joseph J. Duffy, Chicago, Ill. 191,595
5. James McHugh & Son, Chicago, Ill. 191,800
6. E. H. Marhoefer, Jr., Co., Chicago, Ill. 193,172
7. Harvey A. Hanson, Chicago, Ill. 204,854
8. Paschen Constr., Inc., Chicago, Ill. 208,800
9. M. Pontarelli & Sons, Chicago, Ill. 223,378
10. E. L. Archibald Co., Chicago, Ill. 228,423
11. Santucci Constr. Co., Skokie, Ill. 231,500
12. John C. Tully Co., Chicago, Ill. 261,765

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Excavation	5,000 c. y.	$1.50	$1.60	$3.00
2. Sand, gravel, or broken stone fill	1,200 c. y.	1.80	2.20	2.00
3. Class A concrete	2,200 c. y.	16.00	15.75	18.00
4. Class B concrete	25 c. y.	8.00	8.00	8.00
5. Reinforcing steel	285,000 lb.	.0425	.0375	.05
6. Structural steel	540,000 lb.	.085	.089	.08
7. Remove existing concrete	200 c. y.	20.00	16.00	20.00
8. Cinder surfacing	1,250 s. y.	.20	.74	.70
9. Misc. iron castings	10,600 lb.	.08	.13	.08
10. Cast iron pipe and fittings	185,000 lb.	.06	.087	.07
11. 8-in. vitr. sewer pipe	2,650 l. f.	.60	.85	1.00
12. 12-in. vitr. sewer pipe	400 l. f.	1.00	1.10	1.50
13. Miscellaneous pipe work	L. S.	125.00	165.00	300.00
14. Miscellaneous brick work	25 c. y.	25.00	35.00	25.00
15. Special work, pipe lines and drains	L. S.	200.00	800.00	750.00
16. Move track hoist, car puller, hoist house	L. S.	500.00	950.00	350.00
17. Track work	L. S.	14,008.00	12,200.00	9,500.00
18. Dried sludge building	L. S.	28,120.00	27,100.00	27,500.00
19. Dried sludge elevator	L. S.	5,204.00	4,100.00	4,000.00
20. Dried sludge conveyor housing	L. S.	3,767.00	2,900.00	3,000.00



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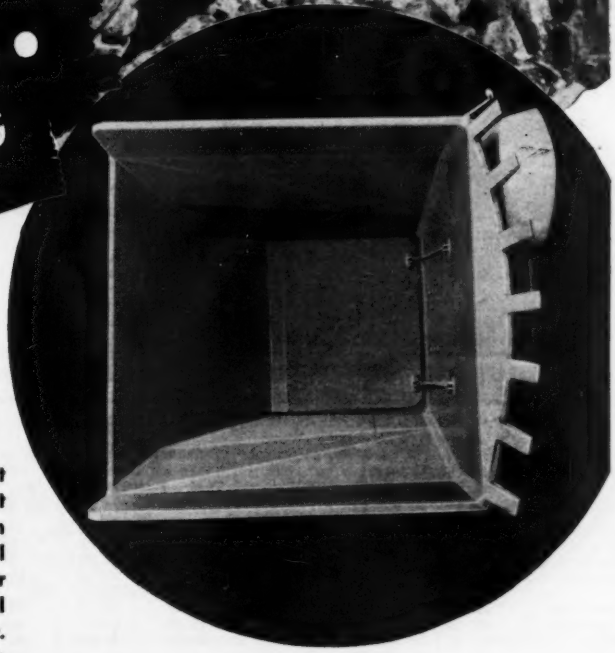

FAST...EASY-LOADING... MORE YARDS PER HOUR

More loads per hour means more yardage per shift . . . and production is what counts today! And that is why the KOEHRING DUMPTOR can help you on those tough schedule jobs. Short wheelbase and full forward operator vision makes it easy to maneuver in tight spots, close to the shovel. That cuts shovel swing time for more passes of the dipper per hour. Wide body top opening makes it easy to spot the dipper load. That saves more time. And then the full speed reverse gets the Dumptor away from the shovel without delay . . . speeding on its way to the fill. *Seconds are saved with every move . . . you get more loads per hour with the KOEHRING DUMPTORS!*

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Wide body top opening permits instantaneous dumping from the shovel dipper, for more loads per hour . . . more yardage per shift . . . lower hauling costs with the KOEHRING DUMPTOR.

KOEHRING HEAVY DUTY

HEAVY-DUTY CONSTRUCTION EQUIPMENT

MATERIALS AND LABOR PRICES

Market quotations on construction materials and wage rates reported monthly by ENR correspondents

HIGHER skilled and common labor wage rates continue to be the most important changes in the construction labor and material price field. Bricklayers' rate is now $1.25 to $1.50 per hour in Birmingham, whereas the lower rate formerly prevailed, and the carpenters' wage is $1.00 to $1.12½, up from the old rate of $1.00 per hour. Hoisting engineers and plasterers in Cleveland now receive $1.75 per hour. Detroit wages are up 10c. per hour for bricklayers, 25c. for carpenters, 12½c. for structural ironworkers and hoisting engineers, but these are subject to further adjustment. New Orleans rate for ironworkers is $1.50 per hour, up 12½c. from the former rate.

Common labor on heavy construction and buildings is now 80c. per hour in Detroit; 50 to 62½c. in Dallas; and 55c. in New Orleans, all substantially above their former levels.

Structural steel shapes are 40c. per 100-lb. higher in Dallas and up 20c. in Philadelphia. Reinforcing bars are up 15c. per 100-lb. in Dallas.

Short leaf yellow pine is $1.00 to $2.00 lower in Birmingham; off $2.00 on 1-in. sizes in New York; but up $2.00 on the same sizes in Baltimore. Douglas fir is higher in Baltimore and Chicago.

The new budget of the Dominion of Canada was presented this week. No new price quotations are available as yet, but a boost in sales taxes is expected to make a change in many of the prices quoted for Montreal which were exempted previously.

CEMENT, AGGREGATES, READY-MIXED CONCRETE—F.O.B. CITY

	PORTLAND CEMENT			SAND AND GRAVEL			CRUSHED STONE		CRUSHED SLAG		CONCRETE
	Per bbl., carload lots, including 40c per bbl. for bags, cash discount not deducted			Per ton, carload lots			Per ton, carload lots		Per ton, carload lots, f.o.b. plant		Ready Mixed 1:2:4, 50 c.y. or more, delivered
	Cloth Bags *a*	Paper Bags	Bulk	Gravel, 1½ in.	Gravel, ¾ in.	Sand	1½ in.	¾ in.	1½ in.	¾ in.	
Atlanta	$2.90	$2.66	$2.61	$1.75	$1.85	$1.95	$1.75	$1.85	$1.55	$1.65	$7.90
Baltimore	2.36	2.11	1.91	1.75‡	1.75‡	1.25‡	1.75‡	1.75‡	1.75‡	1.75‡	6.75
Birmingham	2.50	2.25	2.05	1.75	1.75	1.50	1.00	1.00	.90	1.15	5.80
Boston	2.75*b*	2.50*b*	2.30	1.20‡	1.20‡	.90‡	1.20‡	1.20‡	....	....	6.75*m*
Chicago	2.60	2.35	2.20	2.00‡*d*	2.00‡*d*	2.00‡*d*	2.00‡*d*	2.00‡*d*	1.25‡	1.25‡	....
Cincinnati	2.31	2.06	1.81	1.20	1.20	1.10	1.80	1.80	....	....	6.30
Cleveland	2.00	1.75	....	1.45*i*	1.45*i*	1.30*i*	1.70*i*	1.70*i*	1.70*i*	1.70*i*	6.55*i*
Dallas	2.47	2.22	2.02	1.75*p*	2.00*p*	1.25*p*	1.69*p*	1.84*p*	....	....	6.20
Denver	3.08	2.83	....	1.20	1.40	.90	....	....	....	....	7.25
Detroit	2.24	1.99	1.79	1.55	1.65	.95	1.55	1.65	1.30‡	1.40‡	6.50
Kansas City	2.56	2.31	2.16	1.85	2.30	1.00	1.91	1.91	....	....	7.25*n*
Los Angeles	2.25*b*	2.05*b*	....	1.00	1.00	1.00	1.00*f*	1.00*f*	....	....	5.85
Minneapolis	2.90	2.65	....	1.00*h*	1.00*h*	.25*h*	1.00*h*	1.00*h*	....	....	7.35*j*
Montreal	....	1.82*r*	1.67*r*	....	....	1.25‡	.85‡*c*	1.00‡*c*	....	....	6.45*l*
New Orleans	2.41	2.16	1.96	1.50	1.50	1.25	....	....	....	....	7.25
New York	2.55‡	2.30‡	....	1.40‡*de*	1.40‡*de*	.90‡*de*	1.65‡*de*	1.75‡*de*	....	....	6.50
Philadelphia	2.32	2.07	1.87	1.55‡	1.65‡	1.25‡	....	....	1.00	1.00	7.95*k*
Pittsburgh	2.44	2.19	1.99	1.40‡	1.40‡	1.70‡	2.25‡	2.25‡	1.50	1.50	7.50
St. Louis	2.55	2.30	....	1.50‡	1.50‡	1.25/1.50‡	1.00*h*	1.00*h*	.75*g*	.75*g*	7.75
San Francisco	2.16	1.96	1.66	1.36	1.36	1.36	1.46	1.46	....	....	6.95
Seattle	2.95*o*	2.70*o*	....	1.00*o*	1.00*o*	1.00*o*	2.00*o*	2.00*o*	....	....	7.25

‡ Delivered. *a* 10c. allowed for each returnable bag. *b* 10c. per bbl. off for cash. *c* Plus municipal tax. *d* Per cu. yd. *e* Barge lots alongside docks. *f* Crushed granite. *g* F.o.b. Granite City, Ill. *h* F.o.b. plant. *i* Within three miles of Public Square. *j* 5% discount for cash. *k* Discount 35c. 500 to 2000; 70c. 2000 to 5000; 95c. over 5000. *l* Up to 200 cu. yd. *m* 50c. off for cash. *n* 25 c.y. or more. *o* 2% off for cash. *p* 10c. per ton off, cash 15 days. *r* 10c. per bbl. off, cash 20 days.

CASH DISCOUNTS CEMENT to Contractors: truck delivery. 2% for cash on 10th of month; on carload deliveries, no trucking, same as dealer cash discount 10c. per bbl. for payment within 15 days of date of invoice. Subject discount 10c per bbl. 20 days in Montreal.

CURRENT MAXIMUM PRICES RECEIVED AT CEMENT MILL

Charge for bags not included. For cloth bags, add 40c. per bbl.; 10c. refund allowed for each returnable bag; for paper bags add 15c. per bbl., not refundable.

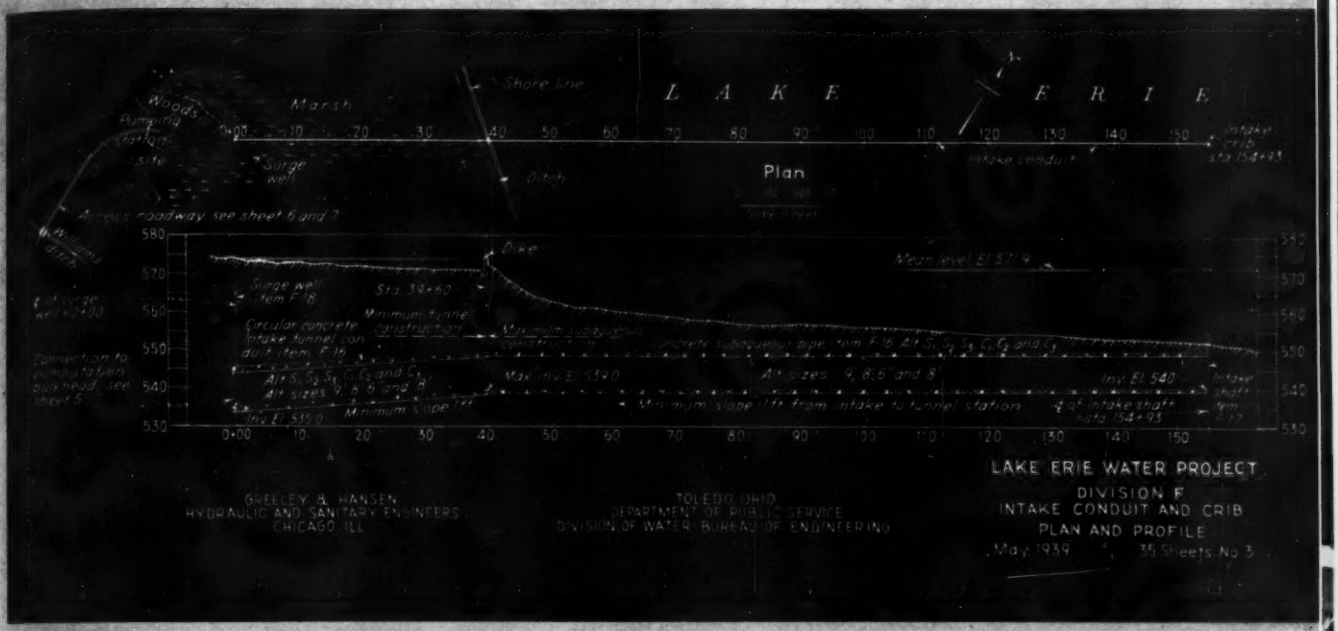
	Bagged	Bulk		Bagged	Bulk		Bagged	Bulk
Buffington, Ind.	$1.70	$1.65	Ironton, Ohio	$1.60	$1.55	Richard City, Tenn.	$1.80	$1.75
Dallas, Tex. (Inc. 5c. tax)	1.80	1.75	Limedale, Ind.	1.70	1.65	Steelton, Minn.	1.80	1.75
Hannibal, Mo.	1.70	1.65	Norfolk, Va.	1.65	1.60	Universal, Pa.	1.65	1.60
Hudson, N. Y.	1.75	1.70	Northampton, Pa.	1.55	1.50	Waco, Tex (5c. tax in Tex.)	1.75	1.70
Independence, Kans.	1.70	1.65	North Birmingham, Ala.	1.70	1.65	Montreal	1.55	1.55

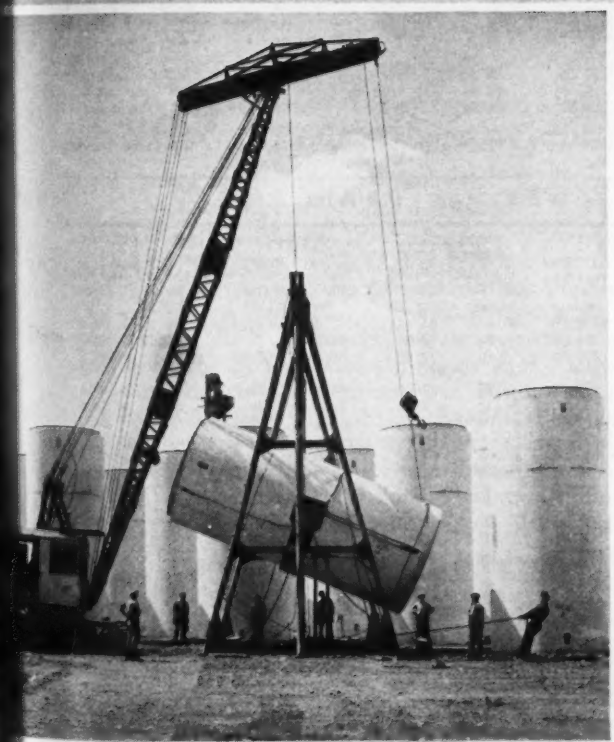
PAVING BRICK, BLOCKS, ASPHALT, ROAD OILS—F.O.B. CITY

	PAVING BRICKS AND BLOCKS			PAVING ASPHALT		ASPHALT BINDERS—FLUXES		CUTBACK ASPHALT		ROAD OILS	ASPHALT EMULSION (Quick-breaking)
	Granite per M. lots of 50,000 4x4x8 in.	Brick per M. 3-4x8½ in. carload lots	Wood per sq. yd. 3½ in. 16-lb. treat	Per ton, less than 80 penetration		Per gal., 80-300 penetration		Per ton		Per gal.	Per gal.
				Tank car	Drums	Tank car	Drums	Tank car	Drums	Tank car	Tank car	Drums
Atlanta	$73.00	$39.35	$2.25	$17.30*e*	$23.83*e*	$0.0695*e*	$0.1018*e*	$0.0734*he*	$0.1257*h*	$0.0634*e*	$0.0734	$0.1257
Baltimore	165.00‡	45.00‡	2.90	14.00	20.00	.06	.09	.065*h*	.115*h*	.....	.....	.....
Birmingham	.....	27.50‡‡	....	18.20	23.20	.0747	.1047	.0834*h*	.1484*h*	.....	.....	.....
Boston	90.00	47.50	3.25	14.00	20.00	.06	.09	.065*h*	.115*h*	.065	.09‡	.12‡
Chicago	150.00	50.00	1.85*d*	14.50	18.50	14.00*g*	18.00*g*	.06*h*	.10*h*	.05	.09	.125
Cincinnati	112.00	37.50	....	13.50	17.50	.07	.....	16.80	.....	.0525	.....	075
Cleveland	110.00	37.50	2.25	15.00	20.00	.065	.075	.075*h*	.085*h*	.035	.08	.09
Dallas	.....	30.00	....	13.25	20.30	.06	.103	15.00	24.80	.055	.05/.07	.07/.09
Denver	.....	27.50	....	....	.....	.....	.....	.....	.....	.....	.....	.....
Detroit	.....	35.00	....	14.10*f*	19.00*f*	.061	.1025	14.10	18.60	.0475	.0645	.098
Kansas City	.....	40.00	....	18.50	23.50	.077	.1075	.077*h*	.107*h*	.057	.11	.15
Los Angeles	.....	50.00	....	6.50*b*	15.00	6.50*bg*	15.00*bg*	5.50*b*	.....	.0192	.0525	.1125
Minneapolis	.....	.....	1.90*d*	21.20	25.70	.10	.12	19.00	29.50	.06	.....	.....
Montreal	75.00	.....	3.62	16.60	24.25	.116	.1483	.115*h*	.135*h*	.08	.135	.188
New Orleans	.....	.....	....	14.00*a*	19.00*a*	.055	.085	.06*h*	.09*h*	.....	.078	.....
New York	.....	.....	2.90	15.00	21.00	.06	.09	.065*h*	.115*h*	.....	.07	.11
Philadelphia	120.00	42.50	2.84	14.00	20.00	.055	.095	.06*h*	.10*h*	.05	.06	.10
Pittsburgh	135.00	38.75	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
St. Louis	110.00/121.00	37.00	....	14.00	19.00	14.00*g*	18.00*g*	.06*h*	.095*h*	.0425	.09	.125
San Francisco	.....	70.00	....	6.50	15.00	6.50*g*	15.00*g*	7.00	17.50	.025	.0525	.1125
Seattle	.....	60.00*c*	....	15.70	24.10	.....	24.10*g*	10.50/11.50	24.00/25.00	8.75*g*	.0575*i*	.1308*i*

‡ Delivered. *a* F.o.b. Baton Rouge. *b* Delivered to purchaser's warehouse. *c* 3½x4x8½ in. *d* 2½ in. 6 to 8-lb. treatment. *e* Local reduction due to 20% reduction intra-state class freight rates, only Georgia affected. *f* Mexican. *g* Per ton. *h* Per gallon. *i* F.o.b. Martinez. *j* 3x3½x8½ in.

LAKE ERIE WATER FOR TOLEDO, OHIO


L A K E E R I E
Shore line
Marsh
Woods
Pumping station site
Surge well
Ditch
Plan
Access roadway see sheet 6 and 7
Dike
Mean level El 571.6
Surge well item F18
Sta 39+60
Minimum tunnel grade
Circular concrete intake tunnel conduit item F16
Connection to pumping station suction header see sheet 5
Air S1 S2 S3 S4 S5 and S6
Air sizes 9, 8.5 and 8
Max Inv El 539.0
Min Inv El 535.0
Minimum slope 1/1
Air sizes 9, 8.5 and 8
Inv El 540
Minimum slope 1/1 from intake to tunnel station
C of intake shaft sta 154+93
Intake crib sta 154+93
Intake conduit
0+00 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
580 570 560 550 540 530
GREELEY & HANSEN HYDRAULIC AND SANITARY ENGINEERS CHICAGO, ILL.
TOLEDO, OHIO DEPARTMENT OF PUBLIC SERVICE DIVISION OF WATER BUREAU OF ENGINEERING
LAKE ERIE WATER PROJECT
DIVISION F
INTAKE CONDUIT AND CRIB
PLAN AND PROFILE
May 1939 35 Sheets No 3



in manufacturing yard at Toledo, Ohio. "Tipping out" a 24 foot length of 108" diameter Lock Joint Reinforced Concrete Subaqueous Pipe.

TOLEDO, Ohio, is now completing its new Lake Erie water supply system.

Two miles from shore lies the intake crib from which this new supply will be drawn. Approximately 10,000 feet of 108" diameter Lock Joint Reinforced Concrete Subaqueous Pipe carries the water from crib to mainland.

This pipe was manufactured right in Toledo using local labor, and to a large extent, local materials. Although it may never be seen by Toledo residents, this Lock Joint Pipe line can be depended upon to deliver water unfailingly. Its permanent construction, water-tight joints and freedom from tuberculation or corrosion assure a long trouble-free life.

Lock Joint Subaqueous Pipe is ideal for cities or industries near large bodies of water. Its many uses include potable water intakes, fresh or salt water intakes for cooling, and outfalls for the disposal of wastes.

Lock Joint Methods assure delivery of the completed pipe line in the shortest possible time. Pressure Pipe can be furnished in sizes from 20" to 150"; and for pressures from zero to over 600 feet of head.

Would you like information and estimates on Lock Joint Pipe for your present or future pipe line installation? We'll be glad to send full details at your request.

PRESSURE • SUBAQUEOUS • SEWER • CULVERT

LOCK JOINT *Reinforced Concrete* PRESSURE PIPE

LOCK JOINT PIPE CO. Established 1905 AMPERE, N. J.

IRON AND STEEL PRODUCTS—BASE MILL PRICES

	STRUCT. SHAPES-PLATE	REINF. BARS ¼-in. f billet b	RIVETS ½-in. structural	WIRE NAILS Base d	SHEET PILING Base	STEEL RAILS Per Gross Ton Standard	Light	Re-rolled	TRACK SUPPLIES Angle Bars	Std. Spikes c	Tie Plates c	Track Bolts
Birmingham	$2.10	$2.15	$3.40	$2.55	.....	$40.00	$40.00	$39.00	$2.70	$3.00	$2.15	$4.15
Chicago	2.10	2.15	3.40	2.55	$2.40	40.00	40.00	39.00	2.70	3.00	2.15	4.15
Pittsburgh	2.10	2.15	3.40	2.55	2.40	40.00	40.00	39.00	2.70	3.00	2.15	4.15
Buffalo	2.10	2.15	.....	.....	2.40	.....	.....	.....	.....	.....	2.15	.....
Cleveland	2.10	2.15	3.40	2.55	.....	.....	.....	.....	.....	.....	.....	.....
Youngstown	.....	2.15	.....	.....	.....	.....	.....	.....	.....	3.00	.....	.....
Detroit	.....	2.25‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gulf ports	2.45a	2.50a	.....	.....	2.85a	.....	.....	.....	.....	.....	.....	.....
Pacific ports	2.75a	2.55a	.....	.....	2.95a	.....	.....	.....	.....	.....	2.30	.....

‡ Delivered. a F.o.b. cars dock. b Rail steel same as billet prices. c Other basing points include Portsmouth, O., Weirton, W. Va., St. Louis, Kansas City, Minnequa, Colo., and Pacific coast ports, on tie plates, alone, Steelton, Pa., on spikes alone, Lebanon, Pa., Richmond, Va. d Add switching charge $18 per o.l.

IRON AND STEEL PRODUCTS—F.O.B. WAREHOUSE, PER 100 LB., BASE PRICE

	STRUCTURAL SHAPES Per 100 lb. base price	REINFORCING BARS* Per 100 lb., ¼ in., base price 15 tons or over b New billet	Rail steel	Add Switch	$/cwt. for Del.	EXPANDED METAL LATH Per 100 sq.yd.. carload lots Std. diamond mesh, 3.4 lb.	Std. ribbed 3.4 lb.	WELDED FABRIC REINFORCING Per 100 s.f.. carload lots 4x16 in., No. 5 & 10 wires	4x12 in., No. 3 & 12 wires	6x6 in. No. 6 & 6 wires Per sq. yd.	SHEET PILING Per 100 lb. base price
Atlanta	$2.34	$2.39	$2.30	.02½	.10	$21.00	$23.00	$1.82	$1.35	$0.1719	$3.04
Baltimore	3.70	2.90	2.75	.....	.10	26.00	28.00	1.70	1.27	.1611	3.00
Birmingham	2.10a	2.15	2.15	.02½	.10	19.00	22.50	1.80	1.34	.1701	....
Boston	3.75	2.61	2.51	$20 C.L.	.10	15.50	17.50	1.76	1.31	.1656	2.77
Chicago	2.10a	2.15	2.05	.03	.05	20.50	22.50	1.67	1.25	.1575	2.40
Cincinnati	3.68	2.51cd	2.41cd	.....	.05	19.50	21.50	1.66	1.25	.1566	....
Cleveland	3.58g	2.15	2.15	.02½	.10	19.50	21.50	1.66	1.25	.1566	....
Dallas	5.30	3.95	3.95	.....	.....	23.50	25.50	1.93	1.42	.1827	....
Denver	4.35	3.95	3.80	.....	.....	24.50	26.50	1.97	1.45	.1863	....
Detroit	3.65‡	2.25	2.15	.....	.10	22.50	24.50	1.68	1.26	.1584	2.66
Kansas City	4.00	2.51cd	2.36cd	.0	.05	17.50	21.00	1.78	1.33	.1683	2.86
Los Angeles	3.65f	2.25	2.10	.02½	.05	23.00	27.50	1.93	1.42	.1827	3.65
Minneapolis	3.80‡	2.48c	2.48c	.0	.10	21.50/22.50	23.50/24.50	1.80	1.34	.1701	2.73d
Montreal	3.90	2.65	2.55	.....	.....	26.00h	33.00h	2.58	3.22	.264	2.58
New Orleans	4.40	2.52	2.52	.05	.10	21.50	23.50	1.82	1.35	.1719	2.875
New York	3.75	2.39	2.39	.....	.10	18.50	20.50	1.76	1.32	.1665	2.74
Philadelphia	3.75	2.66	2.56	.....	.....	19.50	21.50	1.71	1.28	.1611	2.72
Pittsburgh	2.10a	2.15	2.15	.02½	.10	21.50	24.50	1.59	1.20	.1503	2.40
St. Louis	3.69	2.39	2.39	.0	.05	24.50	28.50	1.69	1.27	.1602	2.70
San Francisco	3.90	2.50	2.35	.02½	.10	19.00	25.50	1.93	1.42	.1827	3.25
Seattle	2.75e	2.50e	.....	.....	.....	25.50	27.50	1.93	1.42	.1827	2.95e

‡ Delivered. c Mill prices. b 5–15 tons, add 15c. 1–5 tons, add 25c. Less than 1 ton, add 50c. c 20 tons or over Base. d Mill price plus freight. e F.o.b. dock. f Includes delivery in free delivery zone. g Less than 1 ton, add 25c.; 1 to 5 tons, add 10c. High scrap steel prices cut former 15c. differences between new billet and rail steel in many mills. h List price.

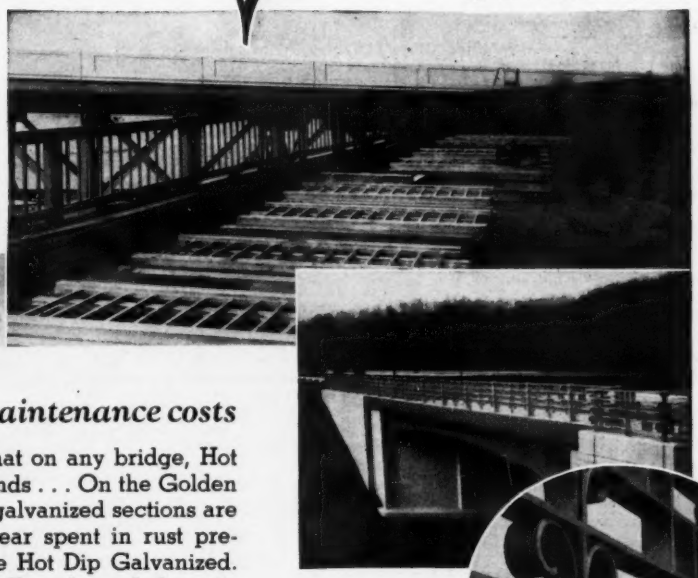
PLUMBING, HEATING, WATER, SEWER AND DRAIN PIPE

	C. I. PIPE Per net ton f.o.b. 6 in. to 24 in.a	VITRIFIED SEWER PIPE Per foot, std. 8 in., s.s.	delivered std. 12 in., s.s.	ASTM 24 in.,	C13–35 36 in.,	CLAY DRAIN TILE Per 1,000 ft., carload lots, f.o.b. 6 in.	8 in.	CONCRETE SEWER PIPE Per ft., delivered; ASTM 12 in.	C 14–35 24 in.	WROUGHT STEEL PIPE Full standard weight, h 1 to 3 in., Butt Weld Black %	Galv. %	3½ to 6in.; Lap Weld Black %	Galv. %
Atlanta	$49 40	$0.26b	$0.468bc	$1.8525	$4.68c	$85.00	$128.00	$0.45	$1.642	62.2	54.2	59.7	51.2
Baltimore	52.80	.45	.70	2.50	6.90	120.00	160.00	.75	2.00	65.5	57.5	63.00	54.5
Birmingham	45.00	.26	.468	1.7875	4.66	85.00	220.00	.40	1.60	62.2	54.2	59.7	51.2
Boston	55.00	.203	.4455	1.98	5.64	115.50‡	228.50‡	.45	1.69	64.1	56.1	61.6	53.1
Chicago	53.80	.28	.54	2.25	6.25	100.00‡	150.00‡	.38	1.48	67.0	59.0	63.5	55.0
Cincinnati	52.70	.196	.378	1.485	4.510	105.00	170.00	.60	1.70	65.9	57.9	63.4	54.9
Cleveland	54.24	.182	.351	1.395	4.305	69.00	108.00	.35	1.50	67.8	59.8	65.3	56.8
Dallas	58.20	.28	.504	2.016	4.70	80.00	100.00	.46	1.57	59.9	51.9	57.3	48.3
Denver	60.60	.24†	.52†	2.16†	.....	130.00	240.00	....	....	58.4	50.4	55.7	47.2
Detroit	54.24	.245	.4725	1.935	4.408	66.45	105.00	.33	1.50	66.3	58.3	63.8	55.3
Kansas City	55.12	.30	.54	2.16	5.00	120.00	240.00	.45	1.60	62.9	54.9	60.0	51.5
Los Angeles	55.00	.282†	.508†	2.034†	5.085†	115.50	192.50	1.00	2.00	59.6	51.6	57.0	48.6
Minneapolis	57.20	.24†	.432†	1.728†	4.60†	.....	.....	.70	1.80	64.2	56.2	60.7	52.2
Montreal	60.00	.55	.90	3.68	5.95e	135.00‡	260.00‡	.48	1.92	.....	.....	.....	....
New Orleans	51.38	.26	.48	1.69	.....	150.00	220.00	.37	2.10	62.4	54.4	58.8	50.3
New York	52.20	.35	.66	2.60	6.70	.....	.....	.50	1.20	64.9	56.8	62.4	53.9i
Philadelphia	50.90	.....	.....	.....	.....	.....	.....	.54	1.80	65.3	57.3	62.8	54.3
Pittsburgh	55.60	.245†	.4725†	1.845†	5.4325	97.80	154.20	.85g	2.00g	68.5i	57.5i	66.0i	54.5
St. Louis	52.48	.24	.432	1.728	3.96	85.00	170.00	.80j	2.00k	65.1	57.1	62.0	53.5
San Francisco	55.00	.3275d	.5895d	2.358	5.895	107.25	178.75	.54	2.50	57.6	49.2	54.8	46.0
Seattle	55.35	.35	.63	2.52	6.30	72.00	175.00	.35f	1.30f	.....	.....	.....	....

‡ Delivered. † F.o.b. a B. & S. class B and heavier, C/L lots, 200 tons and over Burlington, N.J. (base) $49.00. Gas pipe and class A, $3 per ton additional, 4 in., $3 per ton additional, 30 in. and larger usually $2 per ton less. b Double strength. c List to dealer. d List. e 30-inch. f Less 5% for cash. g Culvert pipe. h Discounts from standard list consumers carload prices, except Pittsburgh prices are f.o.b. mill. Base price $200 per net ton. List prices per ft.: ¾ in., 8¢.; 1 in., 11¢.; 1¼ in., 17c.; 2 in., 37c.; 2½ in., 58½c.; 3 in., 76½c.; 4 in., $1.09; 6 in., $1.92. i Applies also at Lorain, Ohio, mills. Chicago delivered base is 2½ points less on butt, 1½ on lap. Freight is figured from Pittsburgh, Lorain, O., Chicago Dist. Billing is from point producing lowest price at destination. WROUGHT IRON PIPE: Base price and list prices per ft. same as wrought steel pipe. Discount for Pittsburgh base: Butt-weld—1 in. and 1¼ in. black 34, galv. 16; 1½ in. black 38, galv. 18½; 2 in. black 37½, galv. 18. Lapweld—2½ in. to 3½ in. black 31½, galv. 14½ in.; 4½ in. to 8 in. black, 32½ galv. 17. j Reinforced; spec. C 76-37. k Reinforced; spec. C 75-37.

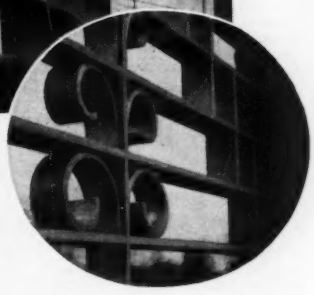
HOT DIP GALVANIZING ★ *solves another problem*

★ *Hot Dip Galvanized Railing on approach to Golden Gate Bridge*



★ *Hot Dip Galvanized Railing, Merritt Parkway, Conn.*

★ *Close-up Merritt Parkway Hot Dip Galvanized Railing.*



An inexpensive answer to maintenance costs

It's a proved mathematical certainty that on any bridge, Hot Dip Galvanizing pays enormous dividends . . . On the Golden Gate Bridge, for instance, original, ungalvanized sections are responsible for over $100,000.00 a year spent in rust prevention . . . *Now*, the new railings are Hot Dip Galvanized. This process of protection removes mill scale and deposits a thick layer of zinc that becomes an inseparable part of the steel beneath. It is the most practical and economical rust protection known to modern science. Patronize our members and *know* that you are getting genuine, durable Hot Dip Galvanizing applied by experts. Write for Specification Sheet and Booklet. American Hot Dip Galvanizers Association, Inc., American Bank Building, Pittsburgh, Pennsylvania.

IF IT CARRIES THIS SEAL IT'S A JOB WELL DONE

Acme Galvanizing, Inc., Milwaukee, Wis. ★ Acme Steel & Malleable Iron Works, Buffalo, N. Y. ★ American Tinning & Galvanizing Co., Erie, Pa. ★ Atlantic Stamping Co., Rochester, N. Y. ★ Atlantic Steel Co., Atlanta, Ga. ★ Buffalo Galvanizing & Tinning Works, Inc., Buffalo, N. Y. ★ Diamond Expansion Bolt Co., Inc., Garwood, N.J. ★ Equipment Steel Products Division of Union Asbestos and Rubber Co., Blue Island, Ill. ★ The Fanner Mfg. Co., Cleveland, O. ★ John Finn Metal Works, San Francisco, Cal. ★ Thomas Gregory Galvanizing Works, Maspeth, N.Y. ★ Hanlon-Gregory Galvanizing Co., Pittsburgh, Pa. ★ James Hill Mfg. Co., Providence, R.I. ★ Hubbard & Co., Oakland, Cal. ★ Independent Galvanizing Co., Newark, N.J. ★ International-Stacey Corp., Columbus, O. ★ Isaacson Iron Works, Seattle, Wash. ★ Joslyn Co. of California, Los Angeles, Cal. ★ Joslyn Mfg. & Supply Co., Chicago, Ill. ★ L. O. Koven & Brother, Inc., Jersey City, N.J. ★ Lehigh Structural Steel Co., Allentown, Pa. ★ Lewis Bolt & Nut Co., Minneapolis, Minn. ★ Missouri Rolling Mill Corp., St. Louis, Mo. ★ The National Telephone Supply Co., Cleveland, O. ★ Penn Galvanizing Co., Philadelphia, Pa. ★ Riverside Foundry & Galvanizing Co., Kalamazoo, Mich. ★ San Francisco Galvanizing Works, San Francisco, Cal. ★ The Sanitary Tinning Co., Cleveland, O. ★ Standard Galvanizing Co., Chicago, Ill. ★ Wilcox, Crittenden & Company, Inc., Middletown, Conn. ★ The Witt Cornice Company, Cincinnati, O.

LUMBER, TIMBER, PLYWOOD—PER M FT., B.M., CARLOAD LOTS F.O.B.

	SHORT LEAF YELLOW PINE AND DOUGLAS FIR — All S. L. Y. P. is No. 2 common or better and for No. 1 N. C. Box. (Prices in Bold Face) *All Fir planks No. 2 common, Fir timber is No. 1 common. Lengths up to 20 ft. (Prices in italics)*									LONG LEAF Y. P. Merchantable grade up to 20 ft.		PLYWOOD* Rail freight increment (See note for base price)	
	1x6 S4S	1x8 S4S	2x4 S4S	2x6 S4S	2x8 S4S	2x10 S4S	3x12 R.L.	6x12 R.L.	12x12 R.L.	2x12 R.L.	12x12 R.L.	¼"	⅜"
Atlanta	**$28.00**	**$28.00**	**$25.00**	**$26.50**	**$26.50**	**$29.50**	**$31.00**	.....	.....	$42.00	$55.00	$17.75	$21.60
Baltimore	**41.00**	**42.00**	**40.00**	**41.00**	**41.00**	**44.00**	**55.00**	.....	.....	80.00	85.00	17.35*g*	21.15*g*
	43.00	*43.00*	*45.00*	*45.00*	*44.00*	*46.00*	*55.00*	*$57.00*	*$58.00*	.....	.....	.....	.....
Birmingham	**26.00**	**26.00**	**24.00**	**24.00**	**24.00**	**28.00**	**48.00**	**46.00**	**46.00**	.....	.....	16.25	19.85
[1]	30.00	30.00	29.00	29.00	30.00	33.00	55.00	.....	.....	58.00	58.00	.....	.....
Boston	**38.00**[3]	**38.00**[3]	**40.00**[3]	45.00	60.00[3]	65.00[3]	80.00[3]	.....	.....	80.00	80.00	17.35*g*	21.15*g*
	58.00	*58.00*	*40.00*	*45.00*	*45.00*	*45.00*	*80.00*	*80.00*	*55.00*	.....	.....	.....	.....
Chicago	**42.00**	**42.00**	**39.00**	**38.00**	**38.00**	**42.00**	**52.00**	.....	.....	90.00	100.00	13.80	16.80
	40.00	*40.00*	*40.00*	*40.00*	*40.00*	*42.00*	*47.00*	*47.00*	*47.00*	.....	.....	.....	.....
Cincinnati	**37.50**	**39.00**	**38.00**	**38.00**	**38.00**	**41.00**	**50.00**	.....	.....	60.00	63.00	16.25	19.85
	.....	.....	.....	.....	.....	.....	*52.00*	*52.00*	*52.00*	.....	.....	.....	.....
Cleveland	**40.00**	**41.00**	**41.00**	**39.00**	**40.00**	**45.00**	**50.00**	50.00	50.00	83.00	83.00	16.70	20.40
Dallas *e*	**38.00**	**39.00**	**38.00**	**36.00**	**37.00**	**38.50**	**52.50**	**52.50**	**52.50**	76.00	81.00	13.90	16.95
Denver ‡	47.00[4]	46.00[4]	50.00[4]	50.00[4]	50.00[4]	52.00[4]	52.00[4]	62.00[4]	65.00[4]	.....	.....	9.90	12.05
Detroit	**42.50**	**42.50**	**41.00**	**42.50**	**42.50**	**44.50**	**51.00**	.....	.....	50.00	59.00	16.25	19.85
	.....	.....	.....	.....	.....	*49.00*	*52.00*	*59.00*	*59.00*	.....	.....	.....	.....
Kansas City	**40.00**	**40.00**	**37.00**	**37.00**	**37.00**	**40.00**	**45.00**	.....	.....	65.00	70.00	12.25	14.95
	42.50	*42.50*	*40.00*	*40.00*	*40.00*	*42.50*	*42.00*	*45.00*	*45.00*	.....	.....	.....	.....
Los Angeles *a*	*40.00*	*40.00*	*39.00*	*39.00*	*36.00*	*36.00*	*48.00*	*48.00*	*48.00*	.....	.....	9.35*gh*	11.35*gh*
Minneapolis ‡*b*	40.00[9]	40.00[9]	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.05	14.70
‡	*42.00*	*42.00*	*42.00*	*40.00*	*40.00*	*42.00*	*46.00*	*53.50*	*53.50*	.....	.....	.....	.....
Montreal [7]	*56.00*	*56.00*	*56.00*	*56.00*	*40.00*	46.00	.....	.....	.....	155.00	165.00	.....	.....
	53.50	*53.50*	*54.25*	*54.25*	*59.25*	*59.25*	*65.00*	*65.00*	*65.00*	.....	.....	.....	.....
New Orleans	**24.00**	**25.00**	**25.00**	**24.00**	**24.00**	**25.00**	**46.00**	.....	.....	62.00	69.00	13.90	16.95
	29.00	*29.00*	*32.00*	*33.00*	*36.00*	*34.00*	*36.00*	.....	.....	.....	.....	.....	.....
New York ‡	**43.00**	**44.00**	**43.00**	**43.00**	**44.00**	**46.00**	**48.00**	.....	.....	85.00*f*	90.00*f*	17.35*g*	21.15*g*
‡	.....	.....	*52.00*	*52.00*	*52.00*	*52.00*	*54.00*	*57.50*	*57.50*	.....	.....	.....	.....
Philadelphia	**24.00**	**24.50**	**25.50**	**25.50**	**27.50**	**27.50**	**29.00**	.....	.....	50.00	57.50	17.35*g*	.1512*g*
	35.00	*36.50*	*39.00*	*38.25*	*39.00*	*39.00*	*44.00*	*52.00*	*52.00*	.....	.....	.....	.....
Pittsburgh	**50.50**	**53.20**	**62.75**	**55.00**	**60.85**	**62.50**	**76.25**	.....	.....	.....	.....	17.00	20.70
	69.50	*68.10*	*66.10*	*65.30*	*65.20*	*65.65*	*88.75*	*88.75*	*88.75*	.....	.....	.....	.....
St. Louis ‡*c*	**40.00**	**41.00**	**39.00**	**38.00**	**39.00**	**40.00**	**52.00**	*58.00*	*58.00*	75.00	74.00	13.90	16.95
San Francisco *d*	*28.00*	*27.00*	*28.00*	*29.50*	*29.00*	*29.50*	*29.50*	*28.00*	*28.00*	.....	.....	7.30*g*	8.90*g*
Seattle	*27.00*	*27.00*	*27.00*	*27.00*	*27.00*	*27.00*	*56.00*	*36.00*	*36.00*	.....	.....	0.00	0.00

Bold Face type, Southern Pine. *Italics, Douglas Fir.* [1] Long leaf. [2] Roofers' N. C. Pine. [3] Spruce. [4] Native. [5] Western Pine, No. 3 Common. [7] Spruce. [9] Norway Pine. ‡ Delivered. *a* Yar prices. *b* Contractors discount in Minneapolis and St. Paul discontinued May 21, 1938. *c* 5M ft. or less. *d* At ship's tackle. *e* 10% discount taken off. *f* Up to 18 ft.

NOTE: Special concrete form grade Fir Plywood, 4' by 8' panels, 5-ply, sanded 2 sides, water resistant glue, carload lots, delivered per 1,000 sq. ft. surface. Seattle base price on ¼", $86.50; on ¾", $95.30; price includes oiling and sealing charges. For other centers add rail freight increment from table or proper size. For resin dipped treatment, add $10.50 per M. *Many mills out of market due to rush of defense orders. *g* Lower rate by water shipment. *h* 50,000 lb. minimum

GLASS, EXPLOSIVES, CHEMICALS

	WINDOW GLASS — Discounts from jobbers list, Aug. 15, 1938 Single or Double Thickness A quality	B quality	EXPLOSIVES — Per lb. 40% Ammonia Gelatin in 50-lb. cases delivered in 200 lb. lots*	
Atlanta	75%	75%	$0.15	
Baltimore	82%	81%	.15	
Birmingham	75%	75%	.105	
Boston	78%	79%	.15	
Chicago	79%	79%	.15	
Cincinnati	77%	77%	.15	
Cleveland	77%	77%	.19	
Dallas	78%	78%	.1625	
Denver	77%	77%	.155*e*	
Detroit	79–10%	79–10%	.15	
Kansas City	77–10%	77–10%	.155	
Los Angeles	86%*d*	88%*d*	.1575	
Minneapolis	76%	76%	.155	
Montreal	40–10%	50–5%	.155†	
New Orleans	70%	75%	.16	
New York	81%	82%	.22*f*	
Philadelphia	82–10%*d*	83–10%*d*	.15	
Pittsburgh	79%	79%	.1225	
St. Louis	77–10%	77–10%	.155	
San Francisco	78%*d*	83%*d*	.155	
Seattle	75%	76%	.1575†	

Price of 60% Ammonia Gelatin is $0.015 per lb. higher than 40%

a Disc. from list Sept. 1939. *b* Also less 6% tax exemption. *d* Discount from jobbers' list Sept. 15, 1928.

* Urban prices influenced by service charges or local storage and delivery regulations, do not consistently reflect quantity prices in less congested areas. *e* F.o.b. Louviers, Colo. *f* In boroughs of Kings, Queens and Richmond, and in Manhattan south of Canal Street, add delivery charge of $6.00 per trip. † F.o.b.

40% Ammonia Gelatin price ranges in other than urban areas, per lb. (except Seismograph Grades)

	C/L 20,000 lb. net	Tons	200 lb. lots
E. of the Miss., except Fla	$0.105	$0.14	$0.16
W. of Miss. to Rocky Mtn. States, and Fla	.11 –.1175	.135 –.1475	.155 –.1675
Rocky Mtn. States	.105 –.1325	.125 –.1375‡	.135–.1525‡
Pacific N. W. States	.1075–.12	.1375–.15	.1575–.17
Pacific S. W. States	.1050–.1175	.135 –.1475	.155 –.1625

‡F.o.b. Louviers, Colo., or Butte, Mont.

PILES, TIES—F.O.B.

PILES

Prices per linear foot, pine, with bark on, f.o.b. New York; delivered from barge 1½ to 2c. per ft. additional:

Dimensions	Points	Length	Short Leaf — Barge	Short Leaf — Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.22	$0.195
12 in.— 2 ft. from butt	6 in.	50 to 59 ft.	.26	.24
12 in.— 2 ft. from butt	6 in.	60 to 69 ft.	.28	.255
14 in.— 2 ft. from butt	6 in.	50 to 69 ft.	.30	.265
14 in.— 2 ft. from butt	6 in.	70 to 79 ft.	.36	.275
14 in.— 2 ft. from butt	5 in.	80 to 85 ft.	.42	.415
14 in.— 2 ft. from butt	5 in.	85 to 89 ft.	.45	.482

RAILWAY TIES

Prices f.o.b., per tie for carload lots:		6"x8"x8' Untr.	6"x8"x8' Tr.	7"x9"x8'6" Untr.	7"x9"x8'6" Tr.
Boston	Oak	$1.20	....	$1.65	....
	Pine	1.50	$2.25*a*	2.25	$3.20*a*
New York	S. L. Sap Pine	1.20/1.30	1.95	1.60	2.55
	Mixed Oak	1.55	2.05	2.00	2.65
Birmingham	White Oak	.85	1.50*a*	1.35	1.70*a*
	Southern Pine	.55*b*	1.10*ab*	.70	1.30*a*
Chicago	Oak	....	1.65*a*	....	2.25*a*
	Southern Pine	....	1.53*a*	....	2.13*a*
Los Angeles	Douglas Fir	.64	1.38*a*	.90	1.80*a*
Philadelphia	Red Oak	1.10	....	....	2.40*a*
St. Louis	White Oak	1.25	....	1.65	....
	Red Oak	1.25	1.70*a*	1.65	2.25*a*
	Sap Pine or Cypress	1.15	....	1.55	....
San Francisco	Douglas Fir	1.00*bcf*	....	....	2.45*caf*
Montreal	Birch or Maple	.65	1.05*a*	.75	1.35*a*

Tr.— Treated; Untr.— Untreated. *a* Creosoted. *b* 6" x 8" x 8'6". *c* Empty cell. *d* Zinc. *e* Green. *f* At ships tackle.

CHEMICALS

Water, sewage treatment, road work, f.o.b. carlots, New York

Bleaching powder, in drums, f.o.b. works, per 100-lb	$2.00–2.85
Chlorine cylinders, liquid, per lb. delivered	.0525
Calcium chloride, 77–80%, flaked, in 400-lb. drums or 100-lb. moisture proof bags, delivered, per ton	20.50–35.00
Silicate of soda, 52 deg., in drums, f.o.b. works, per 100 lb	1.40
Soda ash, 58%, in paper bags, per 100 lb. dense	1.10
Sulphate of aluminum, commercial, in 100-lb. bags, per ton	23.00
Sulphate of copper, in bbl., per 100-lb	4.75

"For Maximum Protection in Mud and Dust, Heat and Cold, we use GULF QUALITY LUBRICANTS"

says this contractor

Actual photo of a Gulf engineer (*right*) discussing lubrication of construction equipment with contractor (*left*) and construction engineer (*center*).

Ralph Myers Construction Company, Salem, Indiana, holds the largest single contract award ever issued by the Pennsylvania Department of Highways. This contract covers relocation of the William Penn Highway over a 6.79 mile stretch between Monroeville and Murraysville, Pennsylvania, near Pittsburgh. The contracting equipment, which is of the very latest type, uses Gulf lubricants and fuels for maximum protection against delays.

"With no time outs and no delays, we are keeping ahead of a tough contract schedule."

"WE find it pays to use only the highest quality lubricants to keep our equipment on the job day in and day out regardless of the operating conditions," says this contractor. "That is why we have standardized on the lubricants recommended by the Gulf engineer."

Call in a Gulf engineer before you start *your* next job —he can help you complete it sooner due to extra hours of trouble-free service from your equipment, at no additional cost. Gulf quality lubricants are quickly available, no matter where your job is located, from more than 1200 warehouses in 30 states from Maine to New Mexico. Phone or write your nearest Gulf office today.

GULF INDUSTRIAL LUBRICATION

GULF OIL CORPORATION · GULF REFINING COMPANY · PITTSBURGH, PA.

STRUCTURAL CLAY BUILDING TILE, BRICK AND LIME—DELIVERED

	STRUCTURAL CLAY TILE — PARTITION — SCORED Per M. lots of 2,000 pieces or over,			STRUCTURAL CLAY TILE — LOAD BEARING — SCORED Per M. lots of 2,000 pieces or over,			BRICK Per M. in quantity,		LIME		
	3x12x12 in.	4x12x12 in.	8x12x12 in.	8x12x12 in.	10x12x12 in.	12x12x12 in.	Common backing	Straight hard	Per ton, Hydrated finishing	In paper, Common hydrated	Carload lot, Pulverized or lump
Atlanta	190.00	$100.00	$185.00	$220.00	$230.00	$240.00	$12.50	$17.00	$26.50	$17.00	$17.00
Baltimore	78.00	85.00	160.00	190.00	235.00	290.00	14.00k	17.00k	19.00	16.00	2.50m
Birmingham	80.00	85.00	160.00	191.00	252.00	285.00	14.00	17.00	18.11	12.64	1.66lo
Boston	98.70a	105.30a	206.85a	236.15	310.85a	346.00a	17.00i	20.00i	19.50	14.91	17.50l
Chicago	68.10	72.60	135.90	185.70	234.90	268.10	11.50	12.50	16.40	14.40	12.20
Cincinnati	61.40	65.30	121.90	141.50	187.30	215.20	16.00	16.00	15.40	13.00	.....
Cleveland	55.55	60.00	112.50	135.00	182.00	209.00	16.00	16.00	15.00j	12.00j	2.75jm
Dallas	50.00	52.00	100.00	135.00	200.00	250.00	11.50i	13.50i	19.00	15.00	.95m
Denver	84.80	94.40	152.70	178.20	212.00	227.90	13.50	17.00	30.00j	19.00j	30.00j
Detroit	69.00	73.60	138.00	176.00	232.00	265.00e	16.00	17.00	16.00	13.75	14.75
Kansas City	64.50	66.50	86.00e	125.50	159.75	186.25	14.50	24.00	19.10	12.80	10.70
Los Angeles	73.50tr	89.50tr	128.00etr	210.00tr	368.00tr	460.00tr	13.50	15.00	16.50	17.50	17.50
Minneapolis	71.45	76.20	143.95	171.45	173.80	242.10	13.10	15.10g	21.00	16.00	19.00
Montreal	72.20a	77.50a	142.50a	76.00at	165.80a	248.70	17.50†	24.25†	23.50	17.00	12.00
New Orleans	72.00	72.00	135.00	162.00	210.00	260.00	14.00	.....	18.30	12.08	14.10
New York	87.00	93.00	128.00e	193.30h	238.80h	295.60h	13.50	.....	19.00	14.00	17.00
Philadelphia	80.50	85.90	161.10	193.30	238.80	295.60	16.00e	18.00e	15.70j	10.05q	12.05q
Pittsburgh	58.40	62.40	116.85	124.00	153.00	193.75	17.00	25.00	17.90	15.40	2.55m
St. Louis	62.00	88.00	120.00	180.00	234.00	280.00	16.00	17.00	22.00	16.00	2 30lm
San Francisco	84.00	94.50	225.00	.....	.....	.....	14.00	17.00	.75o	2.05o	16.40
Seattle	100.00	110.00	220.00	.....	.....	.....	18.00f	22.00f	20.00s	20.00s	20.00s

† F.o.b. a Smooth. t Carload lots delivered to job. c 6x12x12 in. d Not load bearing. e 48 lb. tile. f Less $1.00, ½ cash 15 days, balance 30 days. g Selected common. h F.o.b. Perth Amboy, N. J. i 50c. per M. off for cash. j LCL. k $1.00 discount if paid in 10 days. l Lump. m Per bbl., 180 lb net. n Per sack 100 lb. o Per bbl., 200 lb. p 280 lb. bag. q 25-ton cars. r 5% discount 10 days. s 2% off cash. t 5½ x 8 x 12.

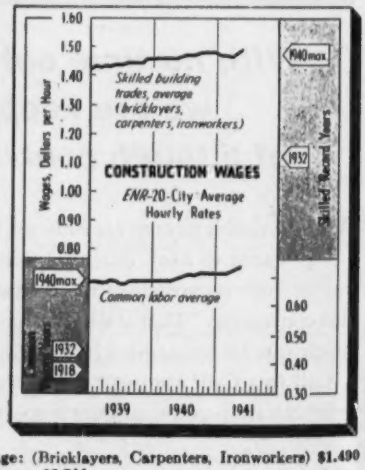
PAINT, ROOFING—F.O.B. CARLOAD LOTS

	RED LEAD Per 100 lb. in 600-lb. (Approx.) bbl.	WHITE LEAD	READY-MIXED PAINT Per gal., drums			ROOFING SUPPLIES Carload lots f.o.b. factory				
	Dry a	Per 100 lb. in oil	Graphite b	Aluminum c	Ferric Oxide d	Rolls, slate surfaced, 85-90 lb. per sq.	Asphalt felt, per 100 lb.	Tar felt, per 100 lb.	Asphalt coating per gal.	Tar pitch 350 lb. bbl. per ton
Atlanta	$9.50	$13.625	$1.30	$2.25	$1.20	$1.90	$1.61	$1.61	$0.27	$29.00
Baltimore	9.25	13.25	1.80	2.75	2.25	2.00	3.25	3.25	.70	2.50m
Birmingham	9.50	13.625	2.35	2.75	1.85	1.98	1.57e	1.57	.32	27.00
Boston	9.25	13.25	1.90‡	2.40‡	1.80‡	1.96‡	1.85Ak‡	1.85Ak‡	.50‡	20.00‡
Chicago	9.25	13.25	2.10	2.63	1.72	1.45kf	1.50kf	1.50kf	.26f	22.00f
Cincinnati	9.25	13.25	1.65	2.85	1.55	2.40	2.39k	2.39k	.36	21.00
Cleveland	9.25	13.25	1.90	2.60	1.60	1.66	1.42k	1.42k	.34	21.00
Dallas	9.25	14.00	1.88	2.11	....	2.50k	2.60k	2.70k	.50	34.00
Denver	9.75	13.75	1.65	2.40	.17i	2.45	4.00	3.00	.35	28.00
Detroit	9.25	13.25	1.75	2.75	1.25	2.40	2.50	2.50	.35	26.00
Kansas City	9.25	13.375	2.15g	2.40g	1.67g	1.93	2.09	2.09	.25	25.00
Los Angeles	9.50	13.75	1.60	2.25	2.30	2.10	1.50	....	.45	.....
Minneapolis	9.25	13.375	....	....	....	1.66i	1.42Aki	1.42Aki	.29	21.00
Montreal	9.25	9.00	2.40	2.97	2.51	2.64	1.85	1.86	.63	1.85k
New York	9.25	13.25	2.02	2.55	1.64	1.83	1.58Ak	1.58Ak	.23	24.00
Philadelphia	9.25	13.25	....	....	....	2.27e	1.94ke	1.94ke	.41e	22.00
Pittsburgh	9.25	13.25	1.05	1.95	.80	1.95	1.94k	1.94k	.36	26.00
St. Louis	9.25	13.25	1.90/2.00	2.60/2.80	1.60/2.00	1.68	1.42	1.42	.27	21.00
San Francisco	9.50	13.50	1.80	2.75	1.10/2.00	1.65	2.26	2.26	.28	17.00
Seattle	9.50	13.75	1.80	2.60	....	1.67	1.18k	1.75	.35	28.00j

‡ Delivered. Note: Red lead in oil 50c. higher than white lead in oil a Red lead prices change frequently due to pig lead price changes. b U. S. War Dept. Spec. 3-49A. c ASTM Spec. D266-31. d 80% minimum ferric oxide. e Subject to 25% discount. f Distributors' price to contractors. g 5 gal. can. k Per roll, 65 lb. i Minneapolis and vicinity. j Asphalt pitch. k Per 100 lb. l Per lb.

SKILLED AND COMMON WAGE RATES—PER HOUR

	Bricklayers	Carpenters	Struct. Iron Workers	Hoisting Engineers	Plasterers	Common Labor Building	Common Labor Heavy Const.
Atlanta	$1.25	$1.00	$1.375	$1.00/1.25	$1.25	$0.40/.50	$0.40/.50
Baltimore	1.50	1.25	1.65	1.50	1.375	.625	.625
Birmingham	1.25/1.50	1.00/1.125	1.50	1.00/1.25	1.25	.40	.40
Boston	1.50	1.25	1.50	1.625	1.625	.60/.85	.60/.85
Chicago	1.70	1.625	1.70	1.70	1.70	1.025	1.025
Cincinnati	1.625	1.45	1.55	1.375/1.525	1.625	.75	.75
Cleveland	1.75	1.50	1.75	1.75	1.75	1.00	1.00
Dallas	1.50	1.00	1.25	1.00	1.50	.50/.625	.50/.625
Denver	1.65b	1.43b	1.43b	1.43b	1.50b	.718b	.718b
Detroit	1.60	1.50g	1.75g	1.625g	1.625g	.80	.80
Kansas City	1.625	1.375	1.50	1.50	1.575	.85	.50
Los Angeles	1.25	1.10	1.375	1.375	1.50	.625	.625
Minneapolis	1.375	1.25d	1.50	1.40	1.50e	.85	.85
New Orleans	1.50	1.25	1.50	1.375	1.375	.55	.55
New York	2.00b	1.85b	2.00	2.00b	2.00e	1.031	.875/.95f
Philadelphia	1.65b	1.40	1.65	1.50	1.75	.70	.70
Pittsburgh	1.75	1.50	1.50	1.25	1.75	.80	.70
St. Louis	1.25/1.50	1.00/1.50	1.75	1.50/2.00	1.25/1.75	.675/.875	.875
San Francisco	1.75c	1.25	1.60	1.50	1.60c	.85/.875	.813
Seattle	1.65	1.35	1.55	1.50	1.65	.95	1.00
Montreal	.80	.70	.75	.65	.80	.45	.40



b 7 hr. day. c 6 hr. day d 35 hr. wk. e 30 hr. wk. f 95c after June 1. g Subject to further adjustment.

ENR Skilled Average: (Bricklayers, Carpenters, Ironworkers) **$1.490**
ENR Common Average: $0.741